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DEPARTMENT OF NATURAL RESOURCES
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DIVISION OF MINES
FERRY BUILDING, SAN FRANCISCO

WALTER W. BRADLEY State Mineralogist

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QUARTERLY CHAPTER
OF
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STATE DIVISION OF MINES
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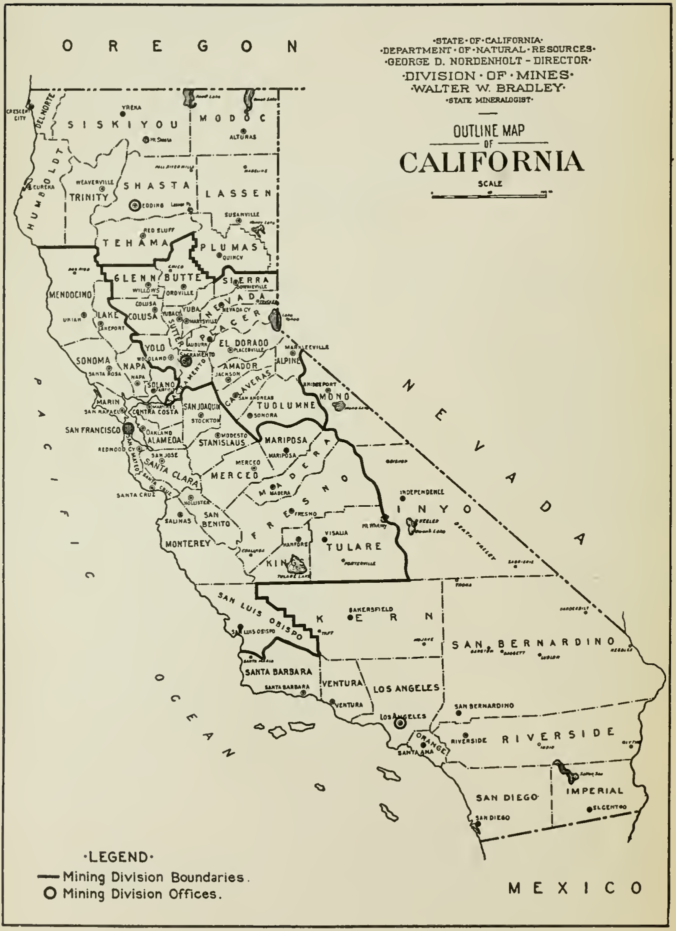

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OUTLINE MAP
OF
CALIFORNIA

SCALE

·LEGEND·
— Mining Division Boundaries.
○ Mining Division Offices.

PREFACE

The Division of Mines (formerly State Mining Bureau) is maintained for the purpose of assisting in all possible ways in the development of California's mineral resources.

As one means of offering tangible service to the mining public, the State Mineralogist for many years has issued an annual or a biennial report reviewing in detail the mines and mineral deposits of the various counties.

As a progressive step in advancing the interests of the mineral industry, and as permitting earlier distribution to the public, publication of the Annual Report of the State Mineralogist in the form of monthly chapters was begun in January, 1922, and continued until March, 1923. Owing to a lack of funds for printing this was changed to a quarterly publication, beginning in September, 1923. For the same reason, beginning with the January, 1924, issue, it became necessary to charge a subscription price. This covers approximately the cost of printing.

Pages are numbered consecutively throughout the year and an index to the complete report is included annually in the closing number.

Beginning with the 1930 issues, the activities and progress of the Geologic Branch are recorded also in these quarterly chapters. The important part that geology plays in the economic development of our mineral resources is further recognized in the change of title from *Mining in California* to CALIFORNIA JOURNAL OF MINES AND GEOLOGY, beginning with the January, 1933, chapter.

While current activities of all descriptions are covered in these chapters, the practice of issuing from time to time technical reports on special subjects will be continued as well. A list of such reports now available is appended hereto, and the names of new bulletins will be added in the future as they are completed.

The chapters are subject to revision, correction and improvement. Constructive suggestions from the mining public will be gladly received, and are invited.

The one aim of the Division of Mines is to increase its usefulness and to stimulate the intelligent development of the wonderful, latent resources of the State of California.

Types of Reports

In general the reports presented in these chapters are grouped into three classes:

1. Mines and mineral resources of a given county or area (describing kind, character, distribution and extent of development).

2. Specific economic and industrial mineral products (listing and describing the resources over the entire state of a given mineral substance, e.g., feldspar).

3. Geological reports on specific areas (recording results and conclusions with maps, derived from field studies; and tied in with economic possibilities and developments).

REPORTS OF DISTRICT MINING ENGINEERS

In 1919–1920 the Mining Bureau was organized into four main geographical divisions, with the field work delegated to a mining engineer in each district, working out from field offices that were established in Redding, Auburn, San Francisco and Los Angeles, respectively. This move brought the office into closer personal contact with operators, and it has many advantages over former methods of conducting field work, including lower traveling-expense bills for the Bureau's engineers. In 1923 the Redding and Auburn field offices were consolidated and moved to Sacramento.

The Redding office was reestablished in 1928, and the boundaries of each district adjusted. The counties now included in each of the four divisions and the locations of the branch offices are shown on the accompanying outline map of the State. (Frontispiece.)

Reports of mining activities and development in each district, prepared by the District Engineer, will continue to appear under the proper field division heading.

MINES AND MINERAL RESOURCES OF SIERRA COUNTY

By Charles V. Averill, District Mining Engineer

OUTLINE OF REPORT

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GEOGRAPHY

Sierra County is one of the northern counties of the Sierra Nevada and hence is quite mountainous with elevations above sea level ranging from 2000 to 8615 feet. The Sierra Nevada continues through Plumas County, which adjoins to the north, but ends just beyond. Deep canyons of branches of the Yuba River cut the west slope of the Sierra Nevada into a series of alternating canyons and ridges trending westward. The North Fork of the Yuba runs through the center of the county and the Middle Fork forms the southern boundary. The mineralized part of the county lies west of the Yuba Pass or west longitude 120°30′.

The farming country of Sierra Valley lies east of the Yuba Pass and drains into the Feather River. A strip along the eastern boundary drains into the adjoining State of Nevada. Land area of Sierra County is 923 square miles and the population by the 1940 census was 3025 persons. The topography of the county is shown on the following topographic sheets of the United States Geological Survey: Downieville, Colfax, Smartsville, Bidwell Bar, Sierraville, and Truckee.

TRANSPORTATION

The best road to Downieville, the county seat, is a hard-surfaced road from the east, the distance from Truckee on the Southern Pacific Railroad being 60 miles and from Loyalton on the Western Pacific being 49 miles. However, this route may be closed for several months in the winter by heavy snows on the Yuba Pass, and this pass is not kept open by snowplows. From Downieville this road continues as a hard-surfaced road to Nevada City, which is served by a narrow-gauge railroad. Most of this stretch is narrow and winding but parts of it were being widened in 1941. This is the only hard-surfaced road of any importance to the mineralized parts of the county. The other hard-surfaced roads are in the farming country of Sierra Valley. Sierra City is on this main road, 13 miles east of Downieville. Roads which cross the grain of the country in a general north and south direction are subject to many turns and steep grades because they must cross the deep canyons and high ridges. Alleghany is 14 miles by a dirt road crossing two high ridges from a point on the paved road 4 miles west of Downieville. Another road called the Foote road runs from Alleghany to Nevada City by the way of Kanaka Creek and North Columbia, a distance of 32 miles.

POWER, WATER, AND TIMBER

The Pike and Alleghany districts are supplied with power from lines of the Pacific Gas and Electric Company, which generates power just to the east in Yuba County at Bullards Bar Dam on the North Fork of the Yuba River. This dam is also available for storage of tailings from hydraulic mining. A few other parts of the county such as the Sierra City district are served by locally generated power, but much of the county is not served by electric power and the mines must either generate their own or use a substitute. Water is abundant throughout the county, but is subject to many existing water rights; hence the amount available to a new operator applying for a new water right may be quite limited. Most of the county is within the Tahoe National Forest and an abundance of good mining timber is available subject, however, to the restrictions of the United States Forest Service.

GEOLOGY

As the geology of Sierra County is the geology of the Sierra Nevada, a brief general description of the geology of that great mountain range is given here. Abundant details are contained in Lindgren's [1] work on the Tertiary gravels and Ferguson's and Gannett's [2] work on the gold quartz veins of the Alleghany district.

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[1] Lindgren, Waldemar, The Tertiary gravels of the Sierra Nevada of California: U. S. Geol. Survey Prof. Paper 73, 1911.

[2] Ferguson, H. G. and Gannett, R. W., Gold quartz veins of the Alleghany district, California: U. S. Geol. Survey Prof. Paper 172, 1932.

See also U. S. Geol. Survey Folios: Downieville, Colfax, Bidwell Bar, Smartsville, Sierraville, Truckee.

The Paleozoic and early Mesozoic seas once extended over the site of the present Sierra Nevada. Toward the close of the Mesozoic era the sediments which had been deposited in those seas were compressed in heavy folds and the intrusion of granitic magmas forced them upward to lofty summits; after the intrusion the fissures and joints of the altered sediments near the contacts of the granitic rocks became filled with veins and seams of gold-bearing quartz. A long period of erosion in the early Cretaceous planed down the mountains, and the concentration of gold from the veins began in the streams after the mountains had been worn down so that these veins were exposed. Pauses in the erosion when the topography had been reduced to gentle outlines permitted deep rock decay and permitted the liberation of gold from its matrix. Renewed uplift quickened erosion and facilitated the further concentration of gold. Throughout Cretaceous and Tertiary times these conditions continued. Fluctuations of the western shoreline at times extended the streams far into the areas now occupied by the Sacramento and San Joaquin valleys, or caused these water courses to debouch upon floodplains reaching high up on the flanks of the range. Faulting movements, with downthrow on the east side, probably beginning in Cretaceous time, had transformed an approximately symmetrical range to a monoclinal one with steep easterly slope. Gradually the mountains were thus reduced to gentler slopes and the canyons widened to valleys. Meandering among longitudinal ridges, the rivers flowed from low divides to rolling foothills and the whole slope was clothed in the dense vegetation of a damp semitropical climate. This was the condition in Eocene time when the most valuable of the Tertiary river gravels were deposited. They contain an abundance of white quartz pebbles and quartz sand, and lack the volcanic rocks of later Tertiary gravel.

Long-quiescent volcanic forces asserted themselves toward the end of Tertiary time, contemporaneously with the greatest volcanic activity in the Great Basin. Rhyolite flows filled the valleys, covered the auriferous gravels, and outlined new stream courses in the old valleys. Renewed disturbance began along the scarcely healed eastern breaks, resulting in a westward tilting of the main blocks, probably combined with normal faulting. In consequence of this disturbance the monoclinal nature of the range became strongly emphasized and the streams immediately began to cut their beds deeper; they repeatedly crossed their old courses and the concentration of gold in the new canyons proceeded under less favorable torrential conditions. Eruptions of andesitic tuffs began in enormous volume and effectually buried a large number of the streams, filling their valleys to the rims. At the close of the Tertiary period a steaming, desolate expanse of volcanic mud covered almost the whole of the northern Sierra, in startling contrast to the peaceable verdure-clad hills of the early Tertiary. In a thousand rills the storm waters flowed down the slope, excavating rapidly in the soft tuffs. The rills became gullies, ravines, creeks, and new master streams. Torrential grades magnified the erosive power, and thus began the canyon-cutting epoch of the late Pliocene and early Quaternary, amazing in its results, as we see them today. The new streams excavated sharp, V-shaped trenches in the hard rock to a depth of 1000 to 4000 feet below the surface of the flows. In many places the old rivers of the Tertiary period were exposed and cross sections of their valleys are now seen on the steep canyon slopes high above the present river beds. Large stretches of the old channels remained secure below their blanket of 1000 feet of hardened volcanic mud. Wherever the canyon-cutting streams destroyed the old channels the gold in those channels became concentrated in the canyons and thousands of disintegrated quartz veins added to the previous concentrates; but owing to the steep grades of the Quaternary rivers much of the detrital material and the fine gold was swept out into the valley at the western foot of the range over alternately advancing and retreating flood plains.

The barren lava flows and the canyon slopes again became clothed by vegetation, this time of the type belonging to a cooler but still temperate climate.

Later in the Quaternary the scenes changed again. The summits became covered with persistent snows which eventually consolidated to névé and to ice. Glaciers filled the upper valleys, but only for a comparatively brief time, disappearing rapidly before the drying winds of a warmer climate and leaving the summit region a desolate expanse of dazzling white, bare granite or reddish schists.

During the last brief span of a few thousand years the Sierra Nevada has remained as we now see it, with the pleasing oak groves of the foothills, the somber giant pines of the middle slopes, and the storm-scarred hemlocks of the summit ridges.

This division has published a map[3] showing the courses of the river channels of the Sierra Nevada as they were in Tertiary time. On the back of the map is printed a description of the general geology of the Sierra Nevada and the Mother Lode.

Remnants of volcanic lava flows and mud flows are found on the tops of present ridges. Canyons of rivers have cut through them exposing parts of the Tertiary rivers. Where the volcanic cover has been removed, the river channels have been mined by the hydraulic method. Where a considerable thickness of volcanic cover remains, the channels have been mined by underground methods or drift mining.

The occurrence of gold in paying quantities in the Tertiary gravels of the Sierra Nevada is limited almost entirely to the gravels in which quartz and metamorphic rocks form the principal components. This is natural because the gold is derived wholly from veins occurring in the metamorphic rocks of the range. In places gold-bearing deposits of primary character are also found in granitic rocks adjacent to the metamorphic area, but these granitic rocks rarely furnish material for pebbles and cobbles on account of their rapid disintegration. A little fine or flour gold is found in the sands and clays which cover the gravels. Gravel beds embedded in the volcanic series and consisting chiefly of andesitic pebbles contain gold only when during their deposition adjacent beds of older gravels or parts of the "Bed-rock series" happened to be exposed to erosion. The Tertiary rocks of the western slope of the range, almost without exception, are barren of precious-metal deposits.

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[3] Jenkins, O. P., Geologic map of the Northern Sierra Nevada showing Tertiary river channels and Mother Lode belt, 1932.

The distribution of detrital gold is strictly dependent on the distribution of primary deposits in the pre-Tertiary sedimentary rocks and to the igneous rocks which are associated with them and which were erupted and metamorphosed before the principal intrusion of the great granitic masses of the Sierra took place. The primary gold deposits were formed shortly after these granitic intrusions. It is a remarkable fact that the large areas of granite in the Sierra are almost wholly barren except close to the contact with the metamorphic series, where smaller veins may begin to appear. About the same time as the main intrusion minor masses of granitic and dioritic rocks were forced into the adjacent older series. In and surrounding these smaller intrusions gold-bearing deposits are particularly abundant. In their distribution, the gold-bearing gravels reflect these conditions in a most accurate manner. The Tertiary and recent rivers traversing the large granite area of the upper part of the range are in general entirely barren, but after entering the metamorphic areas they speedily become charged with auriferous detritus. The amount of gold contained in the streams changes within short distances. Adjacent to the main granite contact, in El Dorado, Amador, and Calaveras counties, are considerable areas of the Calaveras formation—monotonous clay slates or siliceous slates without many areas of igneous rocks. Here the Tertiary channels are poor as a rule, but lower down they become greatly enriched on reaching the areas in which sedimentary and igneous rocks are intimately mingled.

In Sierra, Yuba, and Butte counties the Tertiary channels are rich in gold almost up to the divide of the range, the conditions corresponding to those outlined above. At the point where the State highway to Downieville crosses the county line between Yuba and Sierra counties near Camptonville is the Depot Hill or Joubert hydraulic mine. This is the lowest and most westerly exposure in Sierra County of the Eocene channel of a great river that flowed down from Brandy City and Scales. The river branched at Scales. One tributary came from Poverty Hill, La Porte and Gibsonville. The other came from Port Wine, Queen City, Howland Flat and Potosi. Recent work on the west branch is described herein under the headings of Poverty Hill Properties and Gibsonville Mining Company in the section describing individual mines. The east branch is described under the headings of Lucky Gold Hill Mining Company, Davis Motor Mine, Pioneer, and Loftus Blue Lead, which is at Howland Flat.

Another Eocene channel runs southward from a point high on the ridge south of Downieville and passes through Forest and Alleghany, then joins a channel running southwestward near Moore's Flat. Recent work on this is described herein under the headings of Ruby Mine and Bald Mountain. The Ruby Mine also contains a younger or intervolcanic channel which cuts through the Eocene channel.

The more extensive workings of early years on these channels are described in State Mineralogist's Report XVI for 1917-1918,[4] and in Lindgren's [5] report.

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[4] MacBoyle, Errol, Mines and mineral resources of Sierra county: Calif. State Mineralogist's Report XVI, 1918 (1920).

[5] Op. cit.

In the deep canyons of the forks of Yuba River, the streams have cut through the Tertiary lavas and far down into the underlying formations. On the ridges the volcanic formations of the Tertiary remain. The underlying rocks have received the most detailed study in the vicinity of Alleghany, now the principal lode-gold district of Sierra County. Sedimentary formations occur in belts with north-northwesterly strike and steep to vertical dips, mostly to the east. All belong to the Calaveras formation believed to be of Carboniferous age. The oldest is thought to be the Blue Canyon formation at the east side of the series; the others to be in order with the youngest on the west side. Serpentine dikes with the same strike intrude the series; also masses of gabbro and smaller ones of granite. The sedimentary formations are described in order starting at the east side.

The Blue Canyon formation includes dark, fine-grained fissile slate, which becomes white on weathering, and which grades into shaly, micaceous schist. The formation includes a little conglomerate and quartzite. At a point one and one-half miles east of Alleghany is a major fault which strikes nearly north. The Blue Canyon formation crops out for a width of several miles to the east of this fault.

The Tightner is the next sedimentary formation west of the fault, but with minor exceptions a belt of serpentine lies between it and the Blue Canyon formation. Intrusions of gabbro are found in place of the Tightner formation south of Alleghany. The Tightner formation forms the principal wall rock in the Tightner mine, now part of the Sixteen-to-One mine. It is apparently about 7000 ft. thick. Predominantly the formation consists of fine-grained greenish schist probably derived from andesite, possibly the same as the amphibolite schist of the Mother Lode region farther south. Occasional bands of quartz and a little limestone, conglomerate, chlorite schist, and black slate are included.

The Kanaka formation, several thousand feet in thickness, is the next sedimentary to the west. It includes conglomerate, slate, greenstone, and chert. The conglomerate is not well sorted, and the pebbles are not well rounded; hence it probably has some other origin than marine or fluviatile. It may be of glacial or volcanic origin or perhaps it represents an old talus slope. Dark slates are interbedded with greenstone, which ranges from hornblende schist to material that can be distinguished as originally andesitic or dacitic tuff or breccia. The chert is a dense gray contorted variety interbedded with black slate.

The Relief quartzite, the next formation to the west, is shown in the Colfax folio as a belt striking practically due north a little less than a mile wide. It is more irregular near Alleghany, and intrusions of serpentine, gabbro, and granite have caused metamorphism. The formation consists of quartzite interbedded with clay slates, which have in part been metamorphosed to micaceous schist.

The Cape Horn slate lies west of the Relief Quartzite in a belt one and one-half to five miles wide. It is a very dense black slate similar in general appearance to the slates of the Blue Canyon formation, but is denser and more carbonaceous. In places the slate is much crumpled and lacks the prominent slaty cleavage of the Blue Canyon slate.

Some younger sedimentary formations including at least one Jurassic formation are known in Sierra County, but so far these have not been important as producers of economic minerals in this county. The Mariposa formation of Jurassic age is important farther south along the Mother Lode.

The Tertiary volcanic material capping the ridges, in places 1000 ft. thick, is largely soft andesitic breccia, apparently mud flows. Here and there basaltic lava, 200 ft. thick, overlies it. At drift mines where bedrock tunnels have been driven to mine buried river channels, the workings have occasionally cut quartz veins which have been developed to yield gold ore. Examples are the Rainbow, where a vein beneath the lava cap was discovered in 1858, and Ruby, Telegraph, Red Star, Dead River, North Fork, South Fork, Mugwump, and Tightner. The outstanding one of these is the Tightner, now part of the Sixteen-to-One, at present the best producer in Sierra County. Total production of Sierra Buttes mine has exceeded that of Sixteen-to-One mine.

MINERALOGY, ALLEGHANY DISTRICT

The outstanding feature of Alleghany mineralization is the erratic occurrence of free gold in quartz to make ore of very high grade. Quartz of the vein between the high-grade shoots is likely to be nearly barren. A shipment of ore from the Rainbow mine, weighing 1935 pounds yielded $116,337 in gold. From the same mine a lot of 600 pounds yielded $30,000 in gold. At the Sixteen-to-One mine, a lot of 80 pounds yielded $5,000, and a single piece weighing 160 pounds contained $28,000 in gold.

Alteration of hornblende to chlorite in the schists and gabbro, and alteration of at least a part of the peridotite and pyroxinite to serpentine preceded the filling of the veins by quartz. Accompanying the quartz were the sulphides, pyrite and arsenopyrite. Replacement of some wall rocks by calcic albite and oligoclase, and introduction of a little barite accompanied the quartz. A complex stage followed in which free gold was deposited, accompanied by carbonate (chiefly ankerite), sericite, mariposite, carbon, and several sulphide minerals, pyrite, arsonopyrite, galena, tetrahedrite, sphalerite, chalcopyrite, and jamesonite. These minerals replaced the early quartz along fissures, and a second generation of quartz with opal and chalcedony was deposited also. The result in places is a quartz breccia.

During the carbonate stage of mineralization, wall rocks were extensively replaced by carbonate, sericite, and mariposite. Country rock containing mariposite is bright green in color. The last minerals to be deposited, of no commercial importance, were calcite, pyrite in very small crystals, and possibly marcasite.

ACKNOWLEDGMENTS

The writer wishes to acknowledge the assistance of persons interested in mining throughout the county, particularly George F. Taylor, and Ross F. Taylor, surveyors, Downieville; John Martin, Sierra City; L. L. Huelsdonk, Ruby mine, Goodyears Bar; and C. A. Bennett, Sixteen-to-One mine, Alleghany.

MINERAL RESOURCES

Gold is the principal mineral product, as the distance of the mineral belt from railroads is a handicap to the development of other minerals in competition with deposits closer to rail lines. Chromite, copper, lead, and mineral water have been produced. Iron ore and limestone deposits are known but undeveloped. Molybdenite has been found associated with copper sulphide in prospects in the eastern part of the mineral belt, where the rocks are prevailingly granitic. Asbestos prospects have been located as mining claims. Production since 1880 is given in the accompanying table.

ASBESTOS

Casserly, W. W., of Goodyears Bar had two claims a mile from that place near Goodyears Creek on an asbestos prospect.

Green and Farr Prospect. E. E. Green and I. J. Farr of Sierra City had nine mining claims in sec. 33, T. 20 N., R. 12 E., a mile south of Sierra City by trail. According to Logan [6] long slip fiber amphibole asbestos occurs in schist and serpentine. So far as known to this writer no commercial production has been made.

Lloyd and Milward. Carl L. Lloyd, 498 25th Street, Oakland, and M. S. Milward, Sierra City have recently located 12 claims on asbestos prospects in sec. 30, T. 21 N., R. 12 E., secs. 33, 34, T. 20 N., R. 12 E., secs. 3, 4, T. 19 N., R. 12 E.

CHROMITE

Chromite was mined and shipped from several places in Sierra County during the war of 1914-18. The distance from railroads resulted in high costs of hauling. Some recent activity has been noted during 1941 in four properties as follows:

Milton Chrome Claim is a single claim in sec. 4 (?), T. 19 N., R. 12 E., held by R. C. Zaring, Downieville. The elevation is 7000 ft. and distance by road to Truckee is 40 miles, of which half is rough narrow mountain road by way of Henness Pass.

Chrome ore was mined here during the war of 1914-18, but none was shipped. An upper lens shows about two feet of chrome ore in place, possibly 20 feet long, but most of the bottom of the hole has been covered by sloughing so that the ore can be seen in only one or two places. On the dump at this cut is a pile of 150 tons of mined chrome ore. At a distance of 75 ft. to the east and lower on the mountain side a new lens has recently been developed by Zaring. It is four feet in width and shows a length of 15 ft. The dip is 60° N. On the dump at this cut is 100 tons of mined chrome ore. An analysis of a chunk made by Smith Emery & Co. gave the following results:

Cr_2O_3	40.60%
Fe	11.76%
S	0.22%
P	0.10%

Several tons of float found in the gulch below the deposit may have been eroded from the lenses already developed or possibly from other lenses not yet found.

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[6] Logan, C. A., Sierra County: Calif. State Mineralogist's Report XXV, pp. 154-155, 1929.

MINERAL PRODUCTION OF SIERRA COUNTY, 1880-1940

Year	Gold, value	Silver, value	Miscellaneous stone[1], value	Miscellaneous and unapportioned		
				Amount	Value	Substance
1880	$974,332	$576				
1881	950,000	6,000				
1882	1,100,000					
1883	1,075,000					
1884	1,177,349	145				
1885	1,433,881	11				
1886	1,967,152	2,414				
1887	1,502,469	202				
1888	1,250,000	1,500				
1889	1,446,486	1,222				
1890	733,528	2,039				
1891	701,702	811				
1892	688,464	26				
1893	839,343	46				
1894	604,722					
1895	694,470	107				
1896	786,175	424				
1897	370,208	46				
1898	399,063	519				
1899	450,115	359				
1900	659,696	3,463				
1901	575,427	755				
1902	326,155	311		24,000 gals.	$6,000	Mineral water.
1903	310,770	476				
1904	374,763	1,222				
1905	517,303	3,687				
1906	409,366	2,518				
1907	483,904	2,621		120,000 gals.	12,000	Mineral water.
1908	412,626	1,917				
1909	189,672	957				
1910	312,035	1,330				
1911	461,513	5,604				
1912	732,988	2,777		1,285 lbs. 9,919 lbs.	212 446	Copper. Lead.
1913	1,006,573	4,305		2,228 lbs.	98	Lead.
1914	730,000	3,000				
1915	726,362	3,156				
1916	724,256	3,291			1,950	Other minerals.
1917	384,428	1,629		13,031 lbs.	3,558	Copper.
1918	289,368	2,121		807 tons	40,012	Chromite.
1919	301,172	2,957	$750			
1920	442,894	3,967				
1921	612,267	5,236	2,858			
1922	1,753,242	14,484	2,900			
1923	878,164	6,134	2,312			
1924	799,276	5,198	8,000		2	Other minerals.
1925	1,373,705	8,919	3,677			
1926	564,452	2,913	2,150			
1927	678,873	3,350	70,300		10	Other minerals.
1928	674,855	3,614	1,433		24	Unapportioned.
1929	367,396	1,783	21,223			
1930	589,249	1,056	15,265		15	Unapportioned.
1931	651,754	1,661	37,500			
1932	590,294	2,268	12,965	5,395 lbs. 69,490 lbs.	340 2,005	Copper. Lead.
1933	445,102	1,173	2,833	599 lbs.	38	Copper.
1934	1,027,582	4,546	14,040	757 lbs. 2,104 lbs.	61 78	Copper. Lead.
1935	841,218	3,257	16,069	1,612 lbs. 964 lbs.	134 38	Copper. Lead.
1936	770,945	3,464			13,225	Clay (pottery), gems, granite (tuff).
1937	934,570	3,869		1,213 lbs.	146 36,095	Copper. Other minerals.
1938	900,480	3,109		17,608 lbs.	810 838	Lead. Misc. stone, copper.
1939	864,430	3,177	3,366	4,752 lbs.	223 16	Lead. Other minerals.
1940	958,685	2,854		1,367 lbs.	154 7,630	Copper. Other minerals.
Totals	$45,792,269	$150,576	$217,891		$136,158	

[1] Includes crushed rock, macadam, ballast, rubble, rip-rap, gravel, sand.

Oxford Quartz Mining Company, A. J. Just, secretary, Downieville, M. P. Fisher, president, Downieville, holds property of five patented quartz claims and a 90-acre patented timber claim and eight quartz mining claims unpatented in secs. 22, 23, 26, 27, T. 20 N., R. 10 E. The property is primarily a gold quartz mine but produced about 200 tons of chrome ore during the war of 1914-18.

Chrome ore to the amount of about 20 tons is to be seen at the head of an old cable tram on the mountain. This was mined during the war of 1914-18. It was packed and sledded from points higher on the mountain at distances ranging from a few hundred yards to a mile. The gold quartz vein mentioned above is associated with an andesite dike about 100 ft. wide intruded along a contact of serpentine and slate. Age relations between the serpentine and the andesite could not be determined. The chrome ore came from small lenses in the serpentine near the contact with the andesite. The holes have sloughed to such an extent that nothing can be seen of the occurrence at the present time. Further prospecting was planned in 1941 under the supervision of J. W. White, Downieville. Additional description of the property is given herein under the heading of Gold.

Poker Flat. Several persons including E. R. Jones of La Porte and A. J. Modglin of La Porte have called the attention of the writer to chromite deposits in and near sec. 16, T. 21 N., R. 10 E.

The serpentine belt between Deadwood Creek and Grizzly Creek near Poker Flat contains about 200 tons of chrome ore in sight, mostly in the form of large boulders. The serpentine belt can be reached by a steep and rough mountain road from Downieville to Deadwood of about 15 miles but some additional road will have to be built to reach individual lenses. The road to Poker Flat is too steep for hauling out the chrome ore up the grade and this route is not feasible.

White Bear Mining Company, Richard Belcher, Marysville, holds property in secs. 9, 16, T. 20 N., R. 10 E. which is leased to George R. Costa, R. Daneri, both of Downieville, and E. C. Willis, Hayward. In 1941 the property was being worked as a drift mine for the production of gold, and it is described further under the heading of Gold. During the war of 1914-18 the property produced approximately 1000 tons of chrome ore, and the lessees believe that additional chrome ore can be found in the serpentine belt that crosses the property. Rounded cobbles of chromite have been recovered from the gravel in the drift mine and some of these were being saved in 1941. However, not enough of them have yet been recovered to make this a commercial source of chrome ore.

In addition to the above, the following properties have been reported to contain chrome ore. References to published reports on them are contained in the accompanying table of mines.

Camptonville (Brandy City). sec. 1, T. 19 N., R. 8 E.

Chrome "F." "N." Davis, Bradbury, Dobbie, Forest. sec. 29, T. 19 N., R. 10 E.

Finane, S., Forest. sec. 29, T. 19 N., R. 10 E.

Gibsonville, W. T. Baldwin, Oroville, L. L. Clough, Chamberlin, Quincy. sec. 29, T. 22 N., R. 10 E.

Good Hope. Myers & Case, Downieville. sec. 22, T. 20 N., R. 10 E.

Luce & Co. sec. 1, T. 19 N., R. 8 E.

Macchaus, Hen, et al., Alleghany. sec. 5, T. 18 N., R. 10 E.

Roupe, W. B., Los Angeles. sec. 30, T. 19 N., R. 9 E.

South Star. Ostrom & Lindvall Bros., Downieville. sec. 17, T. 19 N., R. 10 E.

COPPER

Six copper prospects in Sierra County have been listed by MacBoyle,[7] and he states that some production of copper has been made from one of them as noted below. Very little copper has recently been produced in Sierra County.

Sierra Homestake comprises four Sierra Homestake claims and a mill site in sec. 1, T. 20 N., R. 12 E., assessed to Myrtle M. Gallinger, Tahoe City. M. Carvin Gallinger was living on the property in 1941.

Small amounts of both malachite and chalcopyrite have been found on this property associated with white quartz which contains some gold. Gold has been produced on the property and the workings are described in more detail herein under the heading of Gold. No production has been made from the property recently.

Zuver Mine in sec. 19, T. 20 N., R. 12 E., three miles northwest of Sierra City, was held by George Zuver. According to MacBoyle copper sulphides have been extracted and shipped from this property. So far as known to the present writer no recent work has been done.

GOLD

Alaska Mine (Sierra Alaska Mining Company) was discovered in 1863 in washing Texas Ravine. The property was then sold to two different companies and exploited in London and Glasgow. Forty men were working in 1914, and production to that date was said to be $1,000,000 from 100,000 tons of ore. Water averaging 712,000 gallons per day, with a maximum of 1,500,000 gallons per day, was pumped at that time.

About 400 acres patented in secs. 5, 8, T. 18 N., R. 9 E., are assessed to Sierra Alaska Mining Company, Robinson, Price and McDonald, Financial Center Bldg., Oakland. Operations are being conducted by H. L. Sorensen, 685 6th Street, San Francisco, and associates as a partnership. The mine had been shut down since 1916. As indicated above, the mine makes considerable water and when it was reopened on October 8, 1939, new pumping equipment was installed. A little more than 11 months was required for the unwatering and other preliminaries to starting the mill. Pumping equipment was installed as follows: on the 450-level, 5-inch UV Cameron single-stage centrifugal pump, 2300 volt, 125 hp., 3500 r.p.m., 1100 g.p.m.; on the 680-level a pump of the same make and size but with 100 hp. motor. The pump on the 680 level delivers the water to the one on the 450, which pumps to the surface. An electric substation is provided on the 450. Other equipment includes an 800-c.f.m. compressor of 200 hp.

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[7] MacBoyle, Errol, Mines and mineral resources of Sierra County: Calif. State Mineralogist's Report XVI, pp. 30-31, 1918 (1920).

and a new Ingersoll Rand 75-H air cooled compressor of 360 c.f.m. or 75 hp.

Workings on the 680-level have been considerably extended since our report of 1918 was written. The workings are on a vein with a northeast strike and nearly vertical dip and the drift has been extended for about 3000 ft. to the northeast of the vertical shaft. Some faulting at the 2500-ft. point shifts the vein about 60 ft. south. At a point 1500 ft. northeast of the shaft was a place where the vein splits, and the former operators neglected to explore one of the strands of the vein. A crosscut of 16 ft. to the northwest revealed a new orebody practically parallel to the old stope, which was 18 ft. in width. The new stope is called the 626 and is on a 3-ft. vein of ore stated to assay $18 per ton. The old stope was called the Gamma stope and was 60 to 70 ft. long. In connection with opening up the new orebody a total length of 400 ft. of ore has been developed, of which 140 ft. is new. In the east drift an old winze had been sunk to the 795-ft. or No. 7 level and 440 ft. of drifting had been done on the 795-ft. level. Present operators think that this work was done on the south strand of the vein and that they may be able to open up the parallel strand to the north. A new winze is being sunk under the old Gamma stope and this is stated to show 7 ft. of ore at a point 40 ft. below the 680-level. It was full of water at the time of our visit. At a point 450 ft. east of the Gamma stope, a body of ore 140 ft. long called the Dalmy oreshoot has been developed. A winze has been sunk 85 ft. in ore 3 ft. wide from the 680-ft. level. Walls are diorite and slate and either wall may be of either formation but the walls are mostly slate.

The mill on the property contains 40 stamps, 20 of 850 lbs. and 20 of 1050 lbs. Of these, 20 stamps are in use milling 40 tons per day of ore from development work on two shifts. Grinding is to 36 mesh. Plates for amalgamation are used both inside and outside the mortar. Concentrates are made on four Wilfley tables. The mill contains two additional Wifley tables and two Deisters. Some loss occurs in the tailing with this equipment and plans call for the installation of additional equipment. Tests have shown that 58% of the tailing will pass through 100-mesh screen and that this fine material contains 80% of the gold lost. Tailing from amalgamation runs 28% to 29% solids. The plan is to dilute this to 18% solids and treat by flotation in a rougher cell; then concentrate the flotation concentrate on a Wilfley table and return the table tailing to a flotation cleaner cell. The reason for this is that the ore contains considerable talc which goes into a flotation concentrate and it is believed that the talc can be removed by gravity concentration.

R. J. Kohler of Pike is superintendent and B. P. Miller is engineer.

Australia Mine is in secs. 34, 35, T. 20 N., R. 10 E., and is owned by Mrs. Marie E. Phelan, 2226 Capitol Avenue, Sacramento.

This is a single quartz claim between the Finney and Triple Pocket mines, three quarters of a mile south of Downieville. There are three quartz veins on the property, and some high-grade, free gold has been found in pockets. Tunnel No. 1 is said to have produced $12,000 in 1898. It was reopened about 1939 for 75 ft., but no production was made. Only stringers were found.

The property has not been visited, and information was supplied by the owner.

Bald Mountain Mine (Bald Mountain Mining Company) consists of 450 acres unpatented in secs. 15, 21, 22, 27, 28, 29, T. 19 N., R. 10 E., at Forest, owned by Heintzen Estate and N. E. McGregor, Downieville.

It was dicovered in 1869 by a shaft 268 ft. deep. A bedrock tunnel 1800 ft. was run to this point in two years. The cost of putting the property on a paying basis, in 1872, was $20,000. From that time until 1887 the total production was $3,100,000; the net profit $1,300,000, was divided among 20 stockholders. The mine was closed in 1887, but some work was started in 1914 by Mark N. Alling of Downieville and W. F. Copeland of Alameda, and $60,000 is said to have been extracted.

MacBoyle[8] described it as follows in 1918: "The property covers two ancient channels, the 'Great Blue Lead' (now worked out), being the older and the higher, and the 'Deep Mountain Channel,' an intervolcanic channel of the andesitic period. The older channel was worked to the Ruby mine line, where the lava filling of the newer channel cut off the pay gravel almost exactly on the boundary line. This channel comes in from the Ruby claim, crosses the 'Blue Lead' diagonally with a southwest course at the north end of the Bald Mountain ground, courses south along the west side of the 'Blue Lead' in close association with the same, encroaching on the higher lead, more or less, for 3900 ft., when it again crosses the 'Blue Lead' just below the point of confluence of the Bald Mountain Extension tributary with the 'Blue Lead,' there cutting away several hundred feet of the higher channel. The Ruby Company discovered this same deep lead and worked the west benches of it for about 1000 ft. to the Bald Mountain line. Except for 400 ft., the 'Deep Channel' has not been worked from the Ruby line to the south line of the Bald Mountain property. Calaveras slates and amphibolite schists with long parallel lenses of serpentine make up the country rock. Rich quartz ledges occur in the schists and slates along the contacts. Erosion of these by ancient rivers and tributaries accounts for the richness of the ancient channels. The pay gravel ranged from 300 ft. to 600 ft. in width and from 10 ft. to 50 ft. in depth. The gravel was all quartz and quartzites, medium sized to fine; bedrock mostly slate (Calaveras), soft and a good gold catcher. The gold was mostly coarse, nuggets ranging from 1 to 20 ounces being common, with some pieces weighing as much as 73 ounces, though fine gold was also found. Black sands and arsenical sulphides were common. Several quartz ledges were found in the mine, one with free gold in place in the rock; the gravel below where the channel had crossed the ledge was cemented together with sulphides.

In the southern portion of the Ruby ground the 'Deep Bald Mountain Channel' cuts diagonally across and down through the 'Blue Lead,' eroding away about one-half mile of original channel and reconcentrating. This channel was profitably worked by the Ruby Company downstream to their boundary line 3900 ft. further south. The Bald Mountain Company sank an incline into this channel, the gravel being practically all quartz, free and rich in gold. Four hundred feet further south a shaft was sunk into this channel and rich quartz gravel 7 ft. thick was found. About 3200 ft. further south the South Fork

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[8] MacBoyle, Errol, op. cit., p. 32.

Company crossed this channel and found the gravel practically all quartz, and carrying about 50¢ per ton car in gold.''

The Bald Mountain property has been worked recently by Roy Huggens and Oro Huggens who obtained a lease and option and started work on May 24, 1939. Huggens Bros. have been driving the main tunnel at the 4500-ft. point to get under an unworked portion of the intervolcanic channel. McGregor states that at least 3000 ft. of this channel remains unworked in the property. When the mine was visited in July 1941, they were not working but they were planning to resume work.

At the 2000-ft. point in the tunnel a quartz vein has been cut and 700 ft. of drifting was done on it in the years 1918-19. Timbering was repaired in 1938. The strike is north and south and the dip is 45° E. McGregor considers this vein to be a very important prospect on account of its nearness and correspondence in strike to veins of the Alleghany district. The drift could not be entered at time of visit on account of bad air.

The mine is completely equipped with all necessary machinery to develop this vein including a 60-hp. hoist, 17 by 10-inch single-stage Ingersoll Rand compressor, electric storage battery locomotive, good rails and pipe.

Bessler Mine is in sec. 26, T. 20 N., R. 10 E., and is owned by L. and T. Bessler, Downieville. The mine adjoins Downieville townsite on the north at the contact of serpentine and Calaveras (Carboniferous) slate. It made some production years ago, then lay idle until 1916, when it was reopened by the Besslers. It was worked through adits, giving about 150 ft. of backs. The Besslers operated in a small way until 1925 under the name of Downieville Gold Mining Company and produced a small amount of gold. In 1925 the Golden Key Mining Company took a lease and option on the claim and held it until the early part of 1928. They produced a small sum. In 1928 the Mutual Security Company took over the lease and was employing four men in March 1929. The adit work was stopped and a winze was sunk on an angle of 40°. This was in the black slate and reached a depth of 70 ft.

In 1938 H. B. Patton of Los Angeles crosscut 200 ft. east from the bottom of the winze and cut the vein, on which he drifted north for 150 ft. The vein pinched and swelled and had an average width of about 10 inches. Free gold was found in pockets in the vein, which was on a contact between serpentine and slate. Only assessment work is now being done.

Biglow Mine is in sec. 28, T. 20 N., R. 12 E., and is assessed to May E. Goyne, 507 Nevada Street, Nevada City. The mine adjoins the townsite of Sierra City on the north. A quartz vein striking N. 55° W. and dipping 40° E. shows a width of 3 ft. to 14 ft., averaging 5 ft. It has been prospected by a series of adits driven on the lower slope of Sierra Buttes. These adits have prospected a vertical range of about 250 ft. and are connected by a raise 380 ft. long on the vein to the surface.

This property was worked in 1936 and until the winter of 1937. No. 2 level was driven to a total length of 2000 ft. mostly not on the vein. Ore to the amount of $30,000 was produced from old workings at a point in the adit 1300 ft. from the portal, where a stope 100 ft. long was driven. A little stoping was done at the 600-ft. point in the adit. The property is equipped with a mill of 10 stamps, and treatment was amalgamation. Equipment also includes a compressor to supply air for two machine drills, an assay office, and tool shop. Water bought from the Sierra Buttes Company was brought in through 2000 ft. of pipe 11 to 18 inches in diameter under 300 ft. of head. This supplied the power. Property was idle in 1941.

Brush Creek is an old mine on both sides of the point on the main divide between Downieville and Alleghany where the road crosses. An old estimate [9] gives the production to 1875 as $1,000,000. The old workings consisted of an incline shaft 520 ft. in length a short distance south of the Mountain House saddle.

In 1922-23, Ante-Up Mining Company ran a new adit from the north side of the ridge in a southerly direction for 2200 ft. and connected with the old shaft. After sinking a winze 220 ft. deep they struck a small oreshoot and produced a few thousand dollars.

Kate Hardy Mining Company began work in 1927. They sank the winze 95 ft., crosscut 78 ft. to the vein, and developed some low grade ore.

The following claims in secs. 17, 19, 20, 29, 30, T. 19 N., R. 10 E. are assessed to Alpha Stores, Ltd., Nevada City: Mountain House, Mountain House Extension, Judson South Extension, Chromite Extension, Bonnie Brae, Mountain House South Extension, Ben Lomond, Ben Lomond Extension, Liberty Loan No. 1, Liberty Loan No. 2, Bonnie Brae No. 2, Omega.

A new discovery about a mile north of the old workings on this group or two miles south of Goodyears Bar was made in 1941. A quartz vein strikes N. 20° W. and the dip ranges from steep to flat to the west. Probably the dip has been considerably disturbed by surface sliding. A width of 6 ft. to 8 ft. of quartz has been opened up in the bed of a small tributary of Woodruff Creek for a length of 100 ft. This work was started as a bulldozer cut and was continued by handwork to reach a total depth of roughly 20 ft. Some specimen ore showing free gold has been found and an ore bin has been constructed in preparation for an immediate trial mill run. An old adit has been driven into the side of a gulch at a point 100 ft. farther south. At this point the vein appears to have a vertical dip. The vein apparently lies between a chloritic schist and serpentine. The serpentine is on the east side. This new work is a few hundred yards north of the adit run by Ante-Up Mining Company. The adjoining Golden Gate group of claims is held by Andrew Bachels, Goodyears Bar.

Caledonia Development Company, a Nevada corporation, holds the S$\frac{1}{2}$S$\frac{1}{2}$SE$\frac{1}{4}$ sec. 35, T. 20 N., R. 10 E., adjoining the town of Downieville on the opposite side of North Fork of Yuba River. Operations were being conducted in 1941 by Caledonia Operating Company, a partnership of which R. E. Jones, Box 158, Downieville, is a general partner and George L. Patterson, 832 Wall Street, Los Angeles, is a partner.

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[9] Mining and Scientific Press, vol. 31, p. 378, 1875.

A terrace about 30 ft. higher than the river was being mined with a one-yard gasoline power shovel. A bank about 40 ft. high was being carried. Gravel was dumped by the power shovel into a 26-ft. by 54-inch trommel mounted on steel skids. The upper half of the trommel was a scrubber section. The lower half was punched with $\frac{5}{8}$-inch holes. Undersize went to a 12-inch sluice containing 165 ft. of Hungarian riffles spaced from 2 inches to 4 inches apart. Sizes below $\frac{1}{8}$-inch went to an undercurrent; then to rubber riffles; then to jigs. These were two 36-inch Draper jigs made in Nevada City. Plans called for amalgamating the jig concentrates. Capacity of the plant was stated to be 500 cu.yds. per 8 hours, and the operators expected to run two shifts per day. Eight thousand cu.yds. already washed were said to have carried 50¢ per yd. in gold. At the time of visit the trommel was being rebuilt and preparations were being made to set off a large blast in the bank. A crosscut had been started and this was to be driven for 45 ft., then drifts were to be driven 22 ft. each way for a large blast. The total regular crew was expected to be 10 men, 4 men to a shift plus a mechanic and superintendent. Caterpillar 60-hp. bulldozer with a gasoline engine was used to push coarse tailing away from the trommel.

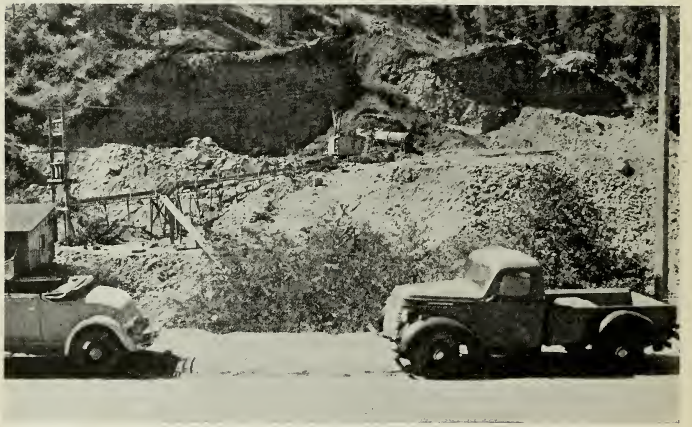

FIG. 1. Caledonia Operating Company

Colombo-Bullion Group is three ane one-half miles northwest of Sierra City in secs. 19, 30, T. 20 N., R. 12 E., and sec. 24, T. 20 N., R. 11 E., at an elevation of more than 5000 ft. The mine was located in 1875, and it was equipped with a 10-stamp mill in 1890.

The operator in 1939 and 1940 was R. D. Compton, Sierra City. The group contains 11 claims, 200 acres, unpatented. A 1900-ft. drift adit starts on the contact between a fine grained igneous rock, probably andesite, and chert. The strike is northwest and the dip is northeast, at about 70°. The last 250 ft. in the tunnel exposed an oreshoot with a flat rake to the northwest and this has been stoped 100 ft. on the dip, 60 ft. long, 3 ft. to 6 ft. wide. The operators think that additional gold-bearing quartz in the hanging wall may bring the vein width up to 12 ft. or more. In the main adit level approximately 1000 ft. of crosscutting has been done into the walls in five different places. A 345-ft. raise connects the lowest or No. 3 level to the highest level. It is driven on an inclination of 35° to 40° and is not on ore. The two higher levels, No. 1 and No. 2 are caved.

The property has been equipped with a cyanide plant consisting of a primary crusher 8 inches by 9 inches; small secondary crusher; ball mill 3-ft. by 4-ft.; Dorr type classifier; three 6-ft. by 30-ft. agitators, steel tanks; 8-ft. by 16-ft. gold tank; 8-ft. by 16-ft. sump; 30-ft. by 6-ft. stock solution tank; 2 small filter bottom tanks, 14-ft. by 5-ft. and 12-ft. by 5-ft. Precipitation is accomplished in a set of 5 zinc boxes, 20-ft. long and by 24-inches wide by 21-inches deep, each divided into 10 compartments of 3 cubic feet each. The first two boxes are used for clarification with excelsior. The capacity of the mill is 12 tons per 24 hours, grinding to minus 60 mesh. Ore milled in the cyanide plant in 1940 amounted to 360 tons. In 1939, 1200 tons of good ore was shipped to a Salt Lake smelter at a profit. According to U. S. Bureau of Mines, Minerals Yearbook for 1940, the yield was 1147 ounces of gold and 40 ounces of silver. The mine was idle on May 21, 1941.

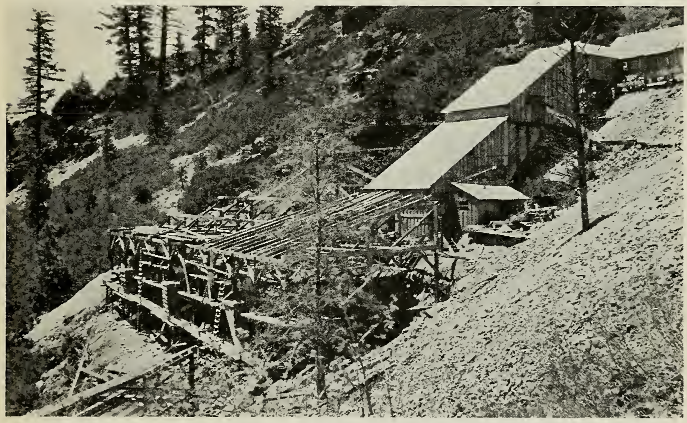

FIG. 2. Cyanide Mill at Colombo-Bullion Mine

Commodore Placer in secs. 2, 3, 4, 5, 8, 9, 10, 11, T. 19 N., R. 12 E., is owned by Mrs. Marie Phelan, 2226 Capitol Ave., Sacramento. The property consists of 1115 acres, of which 160 acres, the Cornish Cabin claim, are patented. It covers 3¼ miles of ancient river channel capped with lava. Some chromite has been found on the Cornish Cabin claim in serpentine bedrock, but no commercial production has been made. Elevation is 4500 ft. to 6500 ft.

Davis Motor Mine (Motor Gravel Mine) is in sec. 23, T. 21 N., R. 9 E. This property is an old drift mine near Queen City, which is said to have been worked years ago by an adit 2000 ft. in length. The mine has recently been reopened by D. M. Davis, La Porte, and the adit has been cleaned out for a length of 1100 ft. The adit follows a contact between soft bedrock, probably slate, and the overlying gravel. The entire length of the tunnel was found to be caved, and the material filling it was gravel from a layer higher than the one that was formerly mined. Gravel removed from the adit was washed but was found to contain very little gold. Davis is planning to continue the work in an effort to get into virgin gravel. He thinks that the channel is 500 ft. or more in width.

Depot Hill Hydraulic Mine is in sec. 19, T. 19 N., R. 9 E., five miles north of Camptonville on the Downieville state highway lateral and at the west county line. It has been worked every season that water has been available since 1855, according to the owner, and is evidently the oldest operating hydraulic mine in the state. For many years it has been the property of the Joubert family. About one and one-quarter miles of channel has been worked but the total production is said to be unknown on account of the number of separate early day holdings later consolidated. At least a million dollars and probably over one and one-quarter millions would be a reasonable estimate of what was produced before 1927.

The deposit is a remnant of the La Porte-Scales-Brandy City channel. The bank of rim gravel is 75 ft. to 110 ft. high and is fine quartz gravel and sand with very few cobbles over six inches in diameter. The pay gravel is a layer 4 ft. to 12 ft. deep next to bedrock, and is often bluish and partly cemented. Above this is a black layer up to three feet thick which is colored by lignitized fragments of wood and other vegetation, and carries numerous nodules of pyrite. This layer evidently marks a period when the stream was ponded and lost velocity because of reaching its grade, after which time the fine gravel and sand was piled up on the rims, due to the stream's loss of transporting power or diminution of flow. This fine, upper gravel is stated by F. J. Joubert, the owner, to be nearly devoid of gold.

The upper gravel is washed off into the sluices as fast as possible, but the lower pay stratum is carefully handled and washed in the pit until it is thoroughly broken up. Some blasting is done. Water is brought to the mine under 160 ft. fall through 7 miles of ditches tapping branches of Indian Creek, Grants Ravine and north and south branches of Oak Valley Creek. A full supply is 600 to 700 miner's inches.

The water duty and capacity of operations are limited by the very flat grade of the ground sluice, only 3 inches in 14 feet. Top gravel is handled twice as fast as the lower pay gravel, but the average daily duty per miner's inch of water is less than a cubic yard. However, the mine has been a profitable one over a long period of years due to careful and intelligent handling, with no unproductive overhead expense. There is 5100 ft. of 2-ft. by 2½-ft. flume, of which 3500 ft. is now in use. It is paved with 7-inch pine-block riffles. Although the gold is all fine, the recovery is reported very high and is made at or near the head of sluice. Tailing storage was formerly behind their own concrete dam, but this was considered full by the California Debris Commission when 500,000 cubic yards had been stored, since which time space behind the Bullard's Bar dam has been purchased.

Frederick Joubert continues to operate the property, usually with one giant with a 5-inch nozzle-opening. The last of the season's water available for the hydraulic giants was being used for cleaning up on July 11, 1941. Two giants with 4-inch nozzle-openings were in use. The channel now being worked is a branch from the old pit and it is not known at this time whether the channel swings back into the main channel in the old pits above or whether it continues for a greater distance. A bank about 80 ft. high and 50 ft. wide was being carried. Bedrock is composed of dioritic and andesitic dikes intruded into slate. Storage charges for tailings have been reduced to 2 cents per cu. yd. The entire bank of gravel averages about 20 cents per cu. yd. in gold, but the top gravel carries only 2 cents per cu. yd., according to Joubert.

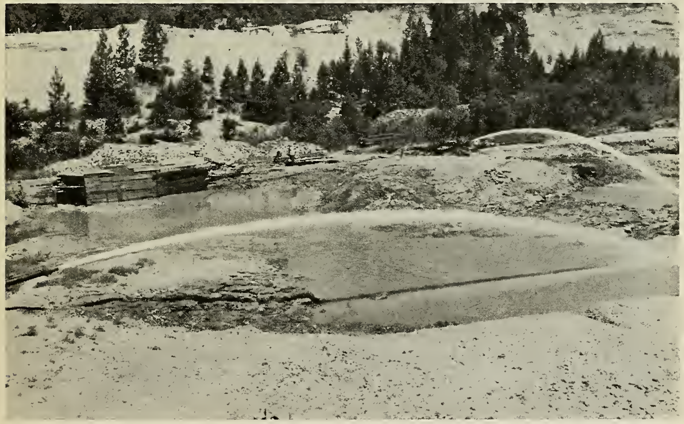

FIG. 3. Depot Hill Hydraulic Mine

Dickey Exploration Company. See Oriental.

Eureka Mine in sec. 7, T. 20 N., R. 10 E., is an old hydraulic mine on which 12 men were employed in 1896, according to State Mineralogist's Report XIII.

Several hundred thousand yards of gravel have been moved here by hydraulic mining from banks that are more than a hundred feet in height. More than half of the material moved was apparently volcanic tuff and volcanic mud overburden. The gravel beneath contains an abundance of white quartz and black chert pebbles. The gravel is partly cemented, and apparently belongs to the Eocene series of gravels. One giant with a 6-inch nozzle-opening was operated during the spring of 1941, but the property had been shut down for the season when it was visited on July 25, 1941. It is 14 miles from a point on the state highway near Camptonville, on a dirt road. Elevation is 5000 ft.

Finney Mine (York) in sec. 35, T. 20 N., R. 10 E., near Downieville, is owned by Gruss Mining Company, and that company was working the property in 1927.

The geologic formations revealed in the workings are those characteristic of the mines on the Alleghany-Downeville serpentine belt. The work follows the contact between the amphibolite schist on the footwall and the Calaveras slate, schist, and dikes on the hanging wall. The vein filling varies from a few inches in places to seven feet in width. The latter width was of the carbonate, quartz, and mariposite rock described in the notes on the Alleghany district, with a quartz seam on each wall.

Gruss Mining Company ran a drift north 150 ft. under the river and south 365 ft. from the bottom of the shaft which is 150 ft. deep. This did not develop any ore, although 'high grade' previously mined had come from the upper part of this shaft.

They also extended the adit to a total length of 1100 ft. early in March 1929. The portal is near the shaft collar, and the direction of adit is south to S. 20° E. It is said to be about 600 ft. below the surface at the face. There appeared to be a length of 600 ft. or more between the 'high grade' York shoot at the shaft, and the point in the adit workings where encouraging prospects were obtained.

The last work was done by Herman Stark, Downieville, from 1930 to 1936. He ran a raise at a point 750 ft. in the tunnel from the York shaft and drove a 250-ft. raise on the vein, which was 3 ft. to 6 ft. in width. The strike was S. 20° E., and the dip was 80° E. A mixture of gouge and quartz is said to have run $12 to $15 per ton. Stark stoped from the raise for a length of 75 ft. Waste was sorted out and left in the stope. He milled about 1800 tons at the rate of about one ton per day.

Ira Mahon, Portland, Oregon, leased the mine in 1937, but milled only about 200 tons of ore. The property was washed out by the high water of December, 1937, and all that now remain are the change house and blacksmith shop.

Gibraltar Mine in secs. 5, 6, 7, 18, T. 21 N., R. 11 E. and T. 21 N., R. 10 E., is owned by Peter and Jake Kieffer, Downieville.

The prospect was first located in 1881 and was worked by Kieffer Brothers for many years; later the Gibraltar Consolidated Mining Company was formed. The work done in these earlier years included an adit 1780 ft. long which proved to be 80 ft. too high, another adit 900 ft. long, and a winze sunk 310 ft. to bedrock at a point 400 ft. back from the face of the adit. Rim gravel was struck in these workings, but water-flow encountered was too great to permit going down into the trough of the channel. Later the company sank a shaft 310 ft. deep and drifted northwest 100 ft. and south 60 ft. In these workings, which were near the west rim, coarse gold was found and a few hundred dollars was produced each year during the short water season.

Gibraltar Sierra Mining Company was incorporated in November, 1925 to develop the property. A new tunnel, designed to cut through the west rim and drain the channel and permit cheaper mining, was started about three-fourths of a mile south of the shaft. After this had been run 1900 ft. without striking gravel, the operators started a raise of 80 ft. back from the face. This was put up 83 ft. and a higher level was started. Late in the fall of 1928 this was about 500 ft. long. Gravel had not yet been found, although rock conditions were reported promising near the face. Another raise was put up over 90 ft. above this upper level, without finding gravel. Work was continued in December, 1928.

The property is equipped with log buildings to house 21 men, a 10-inch by 24-inch compressor, 75 hp. gas engine, ventilating fan, compressed air drill plant, electric light· plant, etc. Gravel had not been found up to April 1, 1929, though nearly 3000 ft. of work had been done.

J. W. White and M. P. Fisher of Downieville have an option on this property of 3000 acres. The tunnel has been driven 4000 ft. in the bedrock of chloritic schist and is designed to cut the channel about the middle of the property. An old 450-ft. tunnel was a little too high to strike the low bedrock channel. It was in soft ground and has been abandoned. The property is 18 miles from Downieville, of which six miles is pack-trail. A seven-ounce piece of gold is said to have been recovered from the shaft. The 4000-ft. tunnel has not yet reached the channel. J. W. White estimates that 200 ft. more of driving is needed.

Gibsonville Mining Company is a partnership of J. H. McMahon, F. R. Powers, and Jerry Mason, Gibsonville. The partnership controls 180 acres covering the townsite of Gibsonville in sec. 30, T. 22 N., R. 10 E. In 1941 they were equipping the property to operate as a hydraulic mine during the next season and expected to mine 500,000 cu. yds. during the season. They planned to use 4000 miner's inches of water from South Fork of Feather River, Slate Creek, Whiskey Creek, and several ravines. During the 1940-41 season 5000 cu. yds. of gravel had been washed as a test.

Golden Gate. See Brush Creek.

Gray Eagle Mine (Gold Point) is in sec. 28, T. 20 N., R. 11 E., six miles east of Downieville and one-half mile north of the highway. As originally located it contained 11 claims and 3 mill sites (in 1914), and was equipped with a stamp mill and electric power, with a dam in the river. After considerable development, financial troubles ensued, due it is claimed to the ore not being amenable to ordinary stamp milling. The claims passed to different owners and no work was done for many years.

In 1928, Yellow Tiger Mining Company took the principal claims under option and cleaned out and sampled the workings and dumps. There is an adit 1125 ft. long, giving up to 300 ft. of backs, and reported to be on the vein for about 700 ft. About 500 ft. from the portal a winze had been sunk 125 ft. According to Gordon Bettles, manager, 150 samples were taken, over widths of 3 to 50 ft. and gave promising assays, indicating a good-sized oreshoot. Only 20 per cent of the gold is free. According to a notice posted on the property, the mine was being worked by Gold Point Mining Company in October, 1933.

In about 1938, ore from Gold Point was run through a flotation plant on the Bigelow property at the rate of 60 to 75 tons per day for the entire summer. The ore is said to have averaged $10 per ton, and tailing assayed 35 cents per ton. Winter-snows put a stop to the hauling, and mining was discontinued, but ore is said to be left in the mine at the present time. The operators said that they would build a mill at Gold Point, but this has not been done. Present owner is Mrs. D. F. Sullivan, Downieville.

The property was idle and deserted when it was visited in 1941; but apparently assessment work was being done. The old stamp mill has burned, but metal parts remain on the property.

Grizzly Hill Hydraulic Mine in sec. 17, T. 19 N., R. 9 E., is owned by Wm. A. Hoff, Indian Valley, Camptonville. This is a hydraulic mine on which three men worked for a short time during the spring of 1941. Water is obtained from Conners Ravine through six miles of ditch, 1000 miner's inches, to supply a 3-inch or 4-inch nozzle under a head of 200 ft. However, only 90 to 100 ft. of head was in use. Operations were on a gravel bank 10 ft. in height. Hoff claims that the property contains three and one-half million yards of gravel similar in kind and grade to that of the Depot Hill Mine of Frederick Joubert.

Hughes Mine in sec. 35, T. 20 N., R. 10 E. adjoining the town of Downieville on the north, is owned by Mrs. Ellen Lawrence, Reno, and sister, Mrs. Emma Darmody, Reno, and is leased to Herman Stark, Downieville. It is said to have produced $70,000 in 1865 and it was equipped with buildings in 1934, but no production resulted.

Indian Hill Mine in secs. 16, 18, 19, 20, T. 19 N., R. 9 E., is seven miles by dirt road north of Camptonville or may be reached by a mile and a half of trail from the crossing of the state highway over Indian Creek, six and one-half miles north of Camptonville, the dirt road being impassable in wet weather. The mine covers only part of the Indian Hill gravel deposit, Zerga and others owning claims on the west and south sides. The elevation of bedrock is 3217 ft., or less than 100 ft. above that at Depot Hill.

The white quartz gravel forming the lower part of the Indian Hill Mine is a remnant of the great La Porte-Scales-Brandy City channel. This gravel, as exposed by previous hydraulic mining on two sides, is similar to that now being mined at Depot Hill. It is 100 ft. or more in depth, of fine white and pink quartz gravel and sand. This quartz gravel is covered at Indian Hill by a later intervolcanic channel containing a great many boulders of schist and lava. If this upper run is to be connected with the gravel drifted at Snowden Hill, three miles east, a very steep grade would be required. Lindgren mentions the Indian Hill quartz channel as being covered at one time with andesitic breccia. This last run of breccia and lava mud forms a layer in places up to 50 ft. thick on top of the intervolcanic channel last mentioned. The intervolcanic gravel on top of the quartz channel is said to carry good pay. A large part of the lower gravel has been worked here in the past by drifting. Hydraulic mining continues on a small scale.

Kate Hardy. See Brush Creek.

Kentucky Mine is in sec. 27, T. 20 N., R. 12 E., one mile east of Sierra City. The property has an area of 30 acres adjoining the Sacred Mount and is owned by Emil Loeffler and Adolph Loeffler, Sierra City. The present owners drove a new level 900 ft. long, of which 300 ft. is drifting on a vein striking northwest and dipping 45° NE. The distance on the dip to the next level above, driven by former owners, is 237 ft. An oreshoot 70 ft. long, 2 to 12 ft. wide, averaging 3½ ft. wide, rakes to the southeast. Stoping has been done on this to a height ranging from 35 ft. to 200 ft. above the new level. The vein has also been stoped from a 25-ft. winze below the level for a length of 40 ft. to 50 ft. Country rock is a fine-grained igneous rock locally called diorite, but some of it may be andesite.

Ore is treated in a mill consisting of 8-inch by 10-inch crusher and ten 900-lb. stamps. Only five of the stamps are used. Treatment is amalgamation on plates and concentration on a Deister table. Output of ore is five tons per day with only two men working, one in the mine and one in the mill.

Water power to operate the mill and a small compressor at the mine is supplied by Wixon Spring. The water is delivered at the mine under 400 ft. of head by means of 1700 ft. of 6-inch, 7-inch and 8-inch pipe.

Kirkpatrick Mine in sec. 15, T. 19 N., R. 10 E., is owned by Charles G. Johnson, State Treasurer, Sacramento. It contains auriferous gravel of a Tertiary river buried beneath hundreds of feet of Tertiary volcanic material. A new contract was reported to have been let in 1941 for 500 ft. of tunnel to get under the channel.

Loftus Blue Lead Mines Co. is controlled by E. A. McKanna, 801 Columbia St., South Pasadena, and James Kelly, La Porte. They have a large group of claims running from St. Louis to Howland Flat, a distance of 4 miles by road, in secs. 31, 32, T. 22 N., R. 10 E., secs. 5, 6, 7, T. 21 N., R. 10 E., sec. 12, T. 21 N., R. 9 E. The property comprises 22 claims, including 15 Loftus claims, Edna Mae (St. Louis), Lone Star, Last Chance, Comet, Belle Kirk, Mystery and the patented Pennsylvania claim, roughly 1500 acres.

Elevation of bedrock in the Wehrle pit, an older pit adjoining the present one, is 5534 ft. Recent work has been in a hydraulic pit in SE¼ SE¼ sec. 31, T. 22 N., R. 10 E., and 100,000 cu. yds. have been removed during the past two seasons from banks that reach a height of 100 ft. Water is brought from the head of Slate Creek through five miles of ditch and is supplied to two giants with 7-inch nozzle-openings through 425 ft. of 36-inch pipe at a head of 90 ft. Bedrock is amphibolite schist. The ground recently mined has been found to have been entirely undermined by drifting years ago and the old timbers are continually being washed out by the hydraulic giants. However, Kelly states that the ground still contains enough gold to pay for mining by the hydraulic method. This is one of the early Tertiary channels, and within 450 ft. from the face of the present pit is an intruded plug of olivine basalt. This peak is called Sugar Loaf and reaches an elevation of 5854 ft.

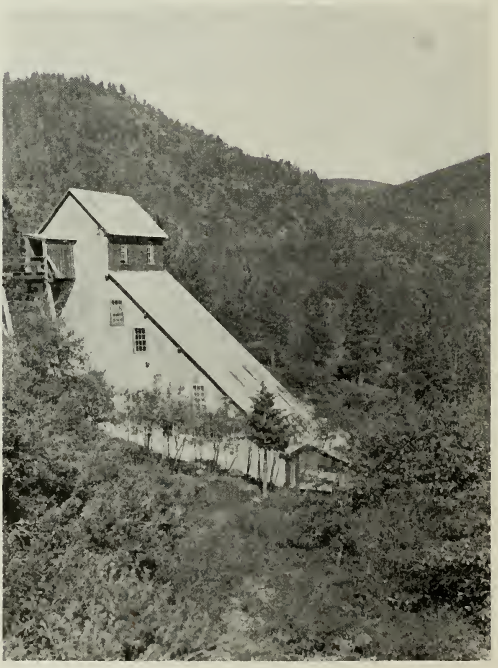

FIG. 4. Mill at Kentucky Mine

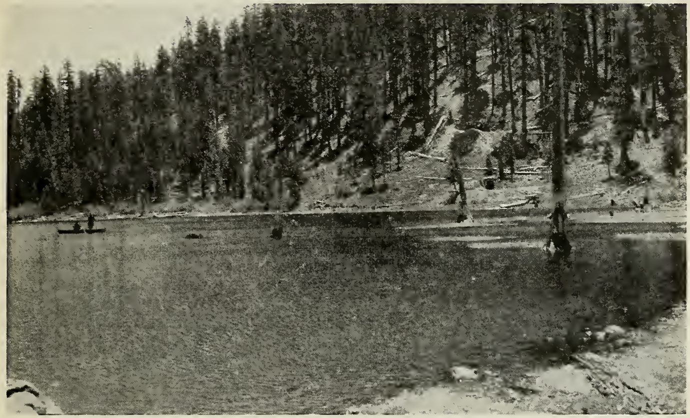

Fig. 5. Lower Salmon Lake. Lone Wolf Group in background

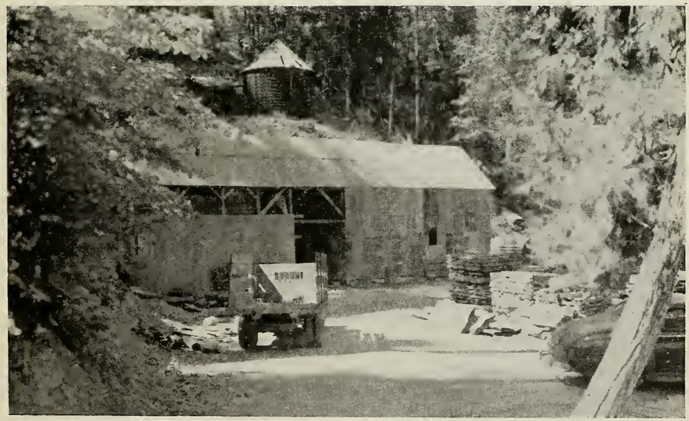

Fig. 6. Lucky Gold Hill Company

Lone Wolf Group is owned by Mark Smith, Sierra City, and is in sec. 28, T. 21 N., R. 12 E. Claims include Lone Wolf, Lone Wolf Extension, Gold Medal, White Horse, Big Jim, an area of 100 acres.

A lower tunnel 80 ft. long follows a 4-ft. quartz vein in diorite for the last 20 ft. The quartz strikes north and dips 41° W. in the face. It is said by Smith to assay $10 to $20 per ton. This is estimated mostly by panning. At a point 50 ft. higher, an adit 10 ft. long exposes a quartz stringer-zone for a width of about 5 ft. Of this width about half is quartz. The dip here is 67°. At a point 50 ft. still higher, a 10-ft. adit exposes a stringer zone. The property is to be developed by J. J. Coan, 35 North 2d Street West, Salt Lake City, Utah. It is on the southwest shore of Lower Salmon Lake, and three quarters of a mile of road is needed to reach it. At the point where the new road will start, a portable compressor is driven by gasoline engine; cars, rails, and other equipment are on hand. These will be put to work soon to finish the road into the mine. A permit for this work from the United States Forest Service was being awaited at time of visit, July 2, 1941.

Lucky Gold Hill Company operates a drift mine in secs. 33, 34, T. 21 N., R. 9 E., and secs. 3, 4, T. 20 N., R. 9 E. The president is Ferrard Leicester, 105 Montgomery Street, San Francisco. Names of the claims are Washington, Iowa, Hardscrabble, Blue Gravel, Bella Union, Poor Boy and five Lucky Gold Hill claims, a total of about 2000 acres. The property was being operated in 1941 by S. W. Cumming, Strawberry Valley, Yuba County, with a crew of 14 men. Cumming stated that the property covers a length of three miles on the Port Wine channel. Work was on the Washington claim, where an adit had been driven a distance of 3000 ft. in a direction N. 70° W. Gravel had just been struck by raising from this adit for 13 ft. The adit is in greenstone. Cumming was washing 50 cu. yds. of gravel per day in the summer of 1941 and was planning to continue the work all winter. He planned to increase the crew to 30 to 40 men, and also gradually to increase the yardage washed. He expected to install a trommel and jigs capable of washing 500 cu. yds. of gravel per day. This outfit was to be designed to save the black sands which are said to contain very substantial amounts of gold.

See references to reports on Blue Gravel Mines Consolidated in the accompanying table of mines.

McCullough Ranch, a 160-acre agricultural patent, is owned by Estate of Joseph J. McCullough, North San Juan, and is in secs. 7, 18, T. 20 N., R. 11 E. In 1941 it was operated by L. A. Roberts Mining Company, Ltd., Box 130, Downieville, a partnership.

The tract apparently contains a deposit of gravel 10 ft. to 14 ft. deep and 200 ft. wide across the entire 160 acres. From the lower end it has been prospected by a hydraulic pit and 200 ft. of tunnel along the bedrock, which is slate. This work is said to have developed gravel which is just about good enough to pay for mining by drifting although large boulders will be troublesome. A few prospect pits have been excavated near the center of the tract. Equipment installed in 1939 includes 2200 ft. of ditch 3 ft. by 5 ft.; 175 ft. of flume 3 ft. by 3 ft.; and 200 ft. of 15-inch and 12-inch pipe. However, this gives only about 25 ft. of head at the prospect pits near the middle of the property, where the best results have recently been obtained. Nuggets weighing as much as 9 oz. are said to have been recovered here recently. Large boulders interfere with both mining and prospecting and the ground has not been systematically prospected. Roberts is planning to equip the property with a 1¼-yd. power shovel. This channel, which is a terrace of a tributary of the Middle Fork of North Fork of Yuba River, is said to have been fed by ancient channels above, the Craycroft and the Wide Awake. See State Mineralogist's Report XVI, pp. 63, 68, for 1918.

Oriental is a quartz mine of the Alleghany District in sec. 33, T. 19 N., R. 10 E., and sec. 4, T. 18 N., R. 10 E. The mine is assessed to *Oriental Mining Company,* H. B. Drescher, Box 527 or Front and K Streets, Sacramento. The operating company is *Dickey Exploration Company,* Mrs. Florence V. V. Dickey, Ojai, Calif. C. B. Foster is in charge at Alleghany.

The property is developed by the main Oriental adit, called the 13th level, which is about 100 ft. above Kanaka Creek. It has been driven a distance of 3800 ft. in the direction N. 5½° E., and drifts have been driven east and west on the Oriental vein. The principal wall-rock is gabbro. In the west drift the Oriental vein strikes west and then swings to the north as the serpentine is approached. The dip is 28° to 50° N. In the crosscut adit a granitic dike was cut in the last 500 ft. The strike is about N. 30° W., and the Oriental vein displaces the dike about 160 ft. horizontally and 200 ft. on the dip. The faulting is reverse. The collar of an old shaft is 780 ft. higher than the adit. The shaft follows the vein, which flattens to a dip of about 30° half way down. At the 8th level a junction is made with what is known as the Alta vein, a flatter vein in the footwall of the Oriental vein. The strike is roughly parallel to that of the Oriental vein and the dip is flat to the north. The splitting of the vein caused some trouble in connecting the shaft below the 10th level with the main adit or 13th level. The dip of the Alta vein must become much steeper between these levels. Present work and present production of ore is on the 7th level of the Alta vein near the shaft, which is 150 ft. west of the main Oriental adit level.

The present mill was designed for treating a disseminated arsenopyrite ore in the granitic dike on the main Oriental adit level. Some mineral has apparently been leached out of this granitic dike and arsenopyrite has been introduced in its place. The dike is porous and easily crushed in the mill. Quartz veinlets are apparently not connected with this arsenopyrite mineralization. Such quartz veinlets in places appear to dilute the ore rather than enrich it. The arsenopyrite mineralization appears to be older than the Oriental vein. For a year the dike was mined by means of a room-and-pillar system, at the rate of 65 to 70 tons per day. Mechanical loading was used. Owing to the fact that men were being attracted to defense work, the property was short of labor in 1941, and the dike was no longer being mined. The crew comprised nine men in 1941. On this granitic ore the concentration ratio of 50 to 1 was maintained in the mill, but on the quartz ore mined from the Alta vein, the concentration ratio was 100 to 1. The arsenopyrite assays 10 oz. gold per ton.

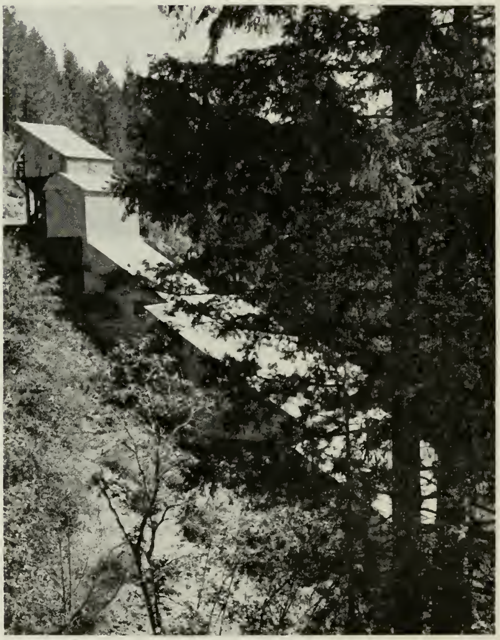

FIG. 7. New mill of Oxford Quartz Mining Company

The mill is a 60-ton flotation plant containing a 10-inch by 20-inch crusher; 5-ft. by 5-ft. ball mill; a jig in the ball-mill-classified circuit; then six No. 18 Denver Equipment Company flotation cells; and a pan batch-type filter for dewatering the concentrate. In 1941 it was treating 20 to 25 tons of ore per day on one shift. Ore from the serpentine areas contains talc and for this reason is troublesome in the mill. Ordinary frothers such as pine oil and cresylic acid float the talc and dilute the concentrate. This has been overcome by using as little as possible of B-23 DuPont frother, which is supposed to be an amyl alcohol.

A map of the principal workings is included in U. S. Geol. Survey Prof. Paper 172, Plate 15, facing page 98.

Oxford Quartz Mining Company is in secs. 22, 23, 26, 27, T. 20 N., R. 10 E., one mile north of Downieville. The president is M. P. Fisher, Downieville, and the secretary is A. J. Just, Downieville. The property now consists of five patented quartz claims, a 90-acre patented timber claim, and eight quartz mining claims unpatented.

The Oxford tunnel, elevation 3455 ft., is a crosscut to the west for a distance of 657 ft. in slate. Then there is a drift for 816 ft. to the north on a vein dipping 72° E. According to a map in the possession of the company the vein varies in width from 2 ft. to 7½ ft. and assays $5 to $44 per ton in gold. Very little stoping has been done between this level and the next level 450 ft. above. The drift should be driven ahead to reach a point under the main oreshoot that was mined from levels above. To the west of these workings serpentine is found, and some production of chrome ore has been made. Further details are contained herein under the heading of chromium.

A new mill on the property includes a 10-inch by 16-inch crusher, Straub ball mill driven by a 50-hp. electric motor, Dorr type classifier, five Denver sub-A flotation cells each about 2 ft. square, two Wilfley type tables, an Oliver drum filter, 3 ft. by 4 ft., for dewatering concentrates. This machinery is housed in a building of steel frame and corrugated iron. A 3000-ft. aerial cable tram with 1000-lb. buckets connects the mill to the next higher level. The mill is on the level of the Oxford tunnel (3455 ft.) described above. The property was idle in 1941.

Pioneer Mine is in secs. 13, 14, 23, 24, T. 21 N., R. 9 E. A consolidation of Pioneer with the adjoining Comet, Challenge, and Riffle claims has been made by W. H. Pike and A. J. Modglin, La Porte. They are planning to equip the property immediately as a hydraulic mine and to bring in water from Cedar Grove Ravine and several other ravines close to the mine. The length of ditch from Cedar Grove will be four miles. The plan calls for two 15-inch lines in the pit and two giants with 6-inch nozzle-openings. The Pioneer was hydraulicked years ago, and the pit is 2000 ft. long and 950 ft. wide, and 40 to 60 ft. in depth. A reservoir of 7 or 8 acres at the head of the property will be used. Gravel to be hydraulicked is estimated to be 80 ft. to 120 ft. in depth.

Poverty Hill Properties is a partnership in which the general partners are A. J. Oyster, W. C. VanFleet, Walter W. Johnson, general

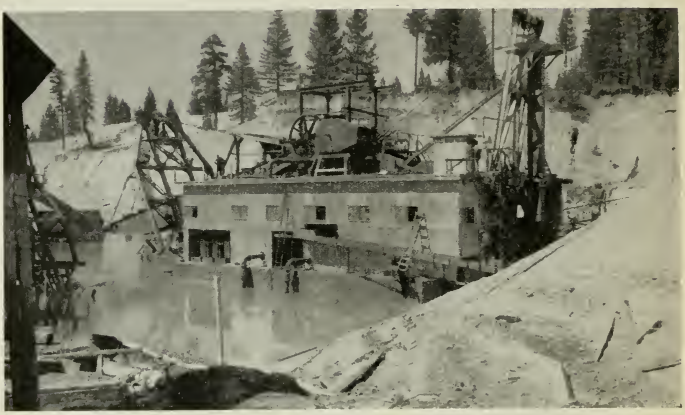

FIG. 8. Poverty Hill Properties, dredge under construction

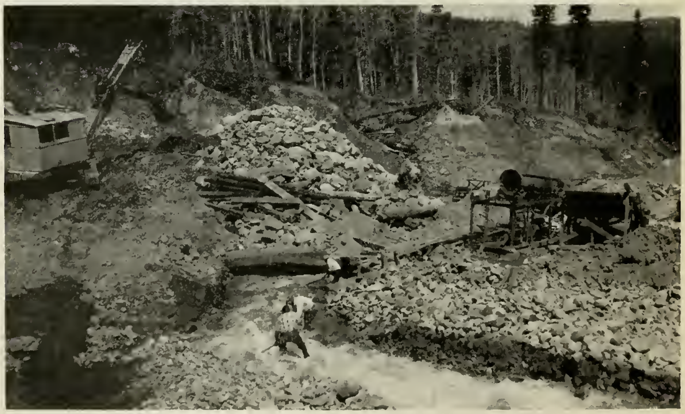

FIG. 9. Pride Mine, new plant under construction

manager, 910 Balfour Bldg., San Francisco. The partnership holds a consolidation of the Bryan and Campbell Co. claim; Gold Valley placer patented to Henry Kingdon on March 5, 1892; Forest King patented to Henry Kingdon, July 21, 1904; East and West National claims, patented to Henry Kingdon, Feb. 3, 1914; Gold Run impounding claims not patented; and Surprise claims; a total of 1100 acres in sec. 32, T. 21 N., R. 9 E. and sec. 5, T. 20 N., R. 9 E.

The deposit is part of the main La Porte channel, occupying a curve. According to Lindgren, ''The channel was a well defined trough about 500 feet deep and one to two miles wide.'' The trough is filled with blue gravel, cemented in places, with large boulders of quartz and slate. This is 10 ft. to 30 ft. deep. Above it is 100 ft. to 120 ft. of fine white quartz gravel and this is covered by white volcanic ash with some quartz pebbles, forming rolling hills, which are in part covered by later andesite. The bedrock in the hydraulic pit is soft schist and green porphyry. The old hydraulic pit in SW¼ sec. 32, T. 21 N., R. 9 E., is 2500 ft. long by 625 ft. to 1000 ft. wide. The deep trough, said to be 150 ft. wide, is reported to contain gravel which will average $2 a cubic yard for a height of five or six feet.

Under construction in the summer of 1941 was a six-cubic-foot bucket line dredge with a hull 88 ft. long, 48 ft. wide, including new pontoons on the side, and 7 ft. deep. This dredge was under construction in a pond in the bottom of one of the old hydraulic pits. Under way also was the stripping of top gravel with caterpillar tractors and carryalls. The plan was to strip to a depth of 40 ft., and then to dredge the lower 40 ft. of gravel. Capacity is estimated at 150,000 yds. per month and the operating season at 8 to 9 months per year. A 16-mile power line has been built from Alleghany to Poverty Hill to carry a total load of 600 hp. The load on the dredge will be 375 hp. Army Adams, Strawberry Valley, Yuba County, is superintendent.

Pride Hydraulic Mine (Paramount and Bradley-Haley) in secs. 11, 13, 14, T. 20 N., R. 12 E., 300 acres, is five miles northeast of Sierra City on Deer Creek and Williams Creek and covers morainal material and gravel supposed to have been derived from the erosion of the channel passing the Hilda and Thousand and One Mines.

The owners are Arthur Pride, and others, Sierra City. Property is being operated by Martin B. Reed and Henry J. Welch, Jr., Sierra City, who have a lease and option. Seven to 10 men were at work in the spring of 1941 installing equipment to wash 1000 cubic yards per day. Mining was to be done with a 1¼-yd. gasoline shovel. Gravel was to be dumped into a grizzly with a 6-inch spacing, from which the oversize was to be stacked by trucks. Undersize was to go to a trommel with ⅝-inch holes and undersize was to be treated on concentrating tables of local design. Oversize from the trommel was to be sluiced. Table concentrate was to be treated in a ball mill to polish the gold; then in an amalgamation barrel. Water for washing and power for Pelton wheels to drive the machinery is supplied from an upper ditch five-eighths of a mile long from Deer Creek giving a 490-foot head. Quantity to be used was estimated at 50 miner's inches.

A mile of channel averages 100 feet in width and 25 ft. to 50 ft. deep. The bedrock in the present pit is granite but a contact of this with schist also exists on the property. Boulders weighing as much as five tons are found in the ground. Tailing is impounded behind the Bullards Bar Dam. Elevation is 5700 feet.

Primrose Mine includes nine patented quartz claims, 167 acres, in secs. 11, 13, 14, T. 20 N., R. 11 E., assessed to Adolph Siebrecht, 206 Judah Street, San Francisco, and M. D. Cogley. The mine was worked in 1888, and some production of gold was made. Residents of Sierra County believe that this property offers opportunity for the development of a profitable gold mine. Some of the old workings are described in State Mineralogist's Report XXV.

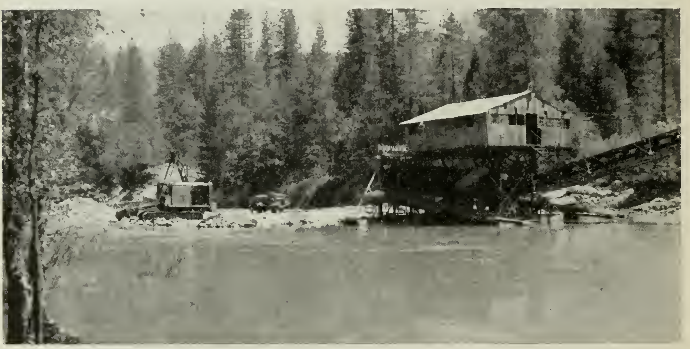

FIG. 10. Wm. Richter and Sons, dragline dredge

Wm. Richter and Sons, Rt. 2, Oroville, were operating a 1½-yd. dragline dredge in 1941 on a 280-acre patented tract owned by Pacific Gas and Electric Company, which includes the Mary Jane placer in secs. 16, 17, T. 19 N., R. 9 E. They expected to operate for one and a half or two years and to dredge 40 or 50 acres of river bars. Capacity of outfit is 1500 cu. yds. per 24 hours and the washing plant is similar to those described in State Mineralogist's Report XXXIV, p. 96, but it is largely of timber construction. Large granite boulders are troublesome, and these are pushed away with a Caterpillar D-8 bulldozer. Bedrock is decomposed granite.

Ruby Mine was being operated in 1941 by C. L. Best, Caterpillar Tractor Company, San Leandro, with L. L. Huelsdonk, Goodyears Bar, in charge. Including a lease on the Mott property, there are 1150 acres, of which 300 are patented, in secs. 10, 11, 14, 15, T. 19 N., R. 10 E. The mine is reached by 15 miles of road from Downieville, mostly steep mountain road, dirt surface.

The Bald Mountain Extension channel, one of the oldest Tertiary channels, branches from the Bald Mountain channel at a point north of Forest. Bald Mountain channel is the same as the Ruby and City-of-Six channels. The last two named are simply continuations of the

Bald Mountain channel to the north. The Bald Mountain Extension channel was worked in the Ruby mine in the 90's from an adit level driven from the side of the mountain on which the town of Forest is located. Present work is on the opposite side of the mountain. An old adit level (portal elevation 4707 ft.) was utilized for a distance of 1800 ft. Work beyond that point is new. The adit is in the Tightner formation for 3320 ft., then in serpentine for 520 ft., then in gabbro and schist for 610 ft., then passes into a second belt of serpentine. A point in the adit is 1850 ft. south of the common corner of secs. 10, 11, 14, 15, T. 19 N., R. 10 E. The contact of the second belt of serpentine and the gabbro-schist is 200 ft. east of the point in the adit just described. The adit then continues in a general southeasterly direction to a point where a raise was put up to the intervolcanic channel. Distance from the portal to this raise is 5850 ft. and the raise is 109 ft. high. From the top of the raise 400 ft. of drifting was done in a southerly direction on the channel and 4000 ft. in north and northeasterly directions on the channel. From this point the channel winds considerably, and 700 ft. more of driving will be needed to connect with the Larry shaft, of which the collar elevation is 5163 ft. and the bottom elevation is 4954 ft. Several thousand feet of additional exploratory work have been driven on the channel, and a connection for air, involving 3000 ft. of work, has been made to the Golden Bear shaft.

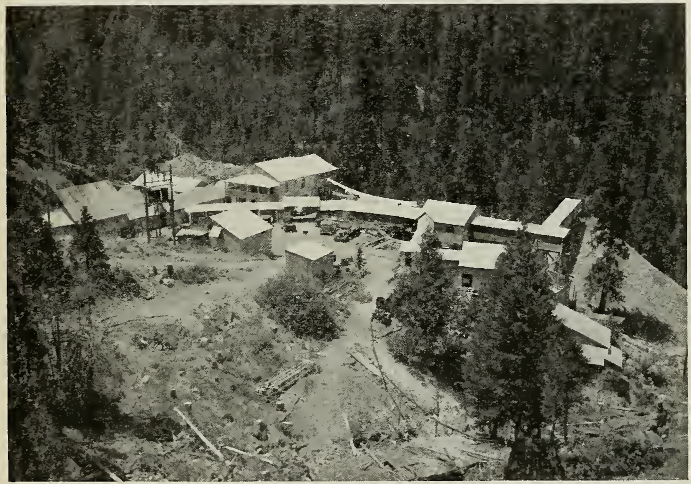

FIG. 11. Ruby Mine, surface plant

The intervolcanic channel that is being worked is 200 ft. lower than the Bald Mountain Extension channel and cut off the Bald Mountain Extension channel. Apparently much of the gold in the intervolcanic channel was derived from the older channel. The intervolcanic channel varies from 60 ft. to 160 ft. in width and is breasted to a height of 6 ft. to 8 ft. Channels are capped by as much as 900 ft. of lava, which is mostly andesite, but basalt is found on top of the andesite in places. Large boulders are stored underground. The finer gravel is moved by slusher scrapers to raise-chutes and hauled in trains by storage battery locomotives to the washing plant at the portal of the main adit level. Timbering comprises stulls and caps specially designed with a mortise and tenon and handled by one man.

In the summer of 1941, the crew comprised 18 men, and 80 to 100 tons of gravel were treated per day, but when the crew was 43 men, 200 tons were treated per day and a maximum of 250 tons was reached. The reason for the small crew in 1941 was that many men had left to engage in defense activities. Gravel passes from storage bin over Hungarian riffles of alloy steel 50 inches wide by 1¼ inches deep; then to a vibrating screen, which is a double screen. The upper screen is of 2-inch square openings, and rods are one-half-inch diameter. The screen which is below is four-mesh of No. 12 wire. Undersize goes to a six-unit Huelsdonk table 20 ft. long by 7 ft. wide. The washing plant will treat 500 tons of gravel per 24 hours. The screen mentioned above is vibrated by an eccentric and 20-hp. motor with a 3¾-inch stroke at the rate of 200 vibrations per minute. Undersize goes to the Huelsdonk table mentioned above, which is vibrated with a ¾-inch to 1-inch stroke at a rate of 200 vibrations per minute. The end of

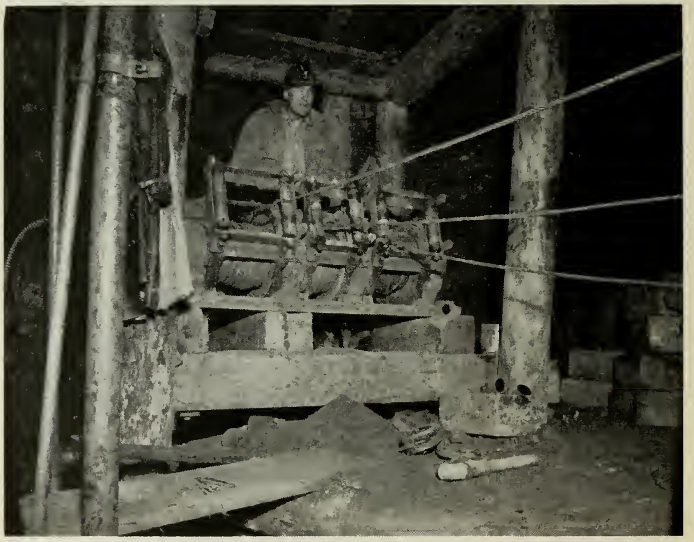

FIG. 12. Ruby Mine, underground slusher hoist. *Photo by courtesy L. L. Huelsdonk*

the table farthest from the vibrating screen is set three-quarters of an inch lower than the end near the screen. Recovery amounting to 10% to 20% of the total is made on this table as fine gold. The remainder is made on the first riffle and the screen about equally divided. Steel bars are placed across the screen to hold it down and these have a tendency to act as riffles. Below the screen additional riffles are provided in the sluice that carries away the oversize, but little gold is recovered from these. Nuggets as big as 52.33 oz. valued at $1,758 have been recovered. C. L. Best is saving all nuggets above $100 in value for exhibit purposes and in 1941 had a collection of 123 that had been recovered since 1937. Gold is 940 to 950 in fineness.

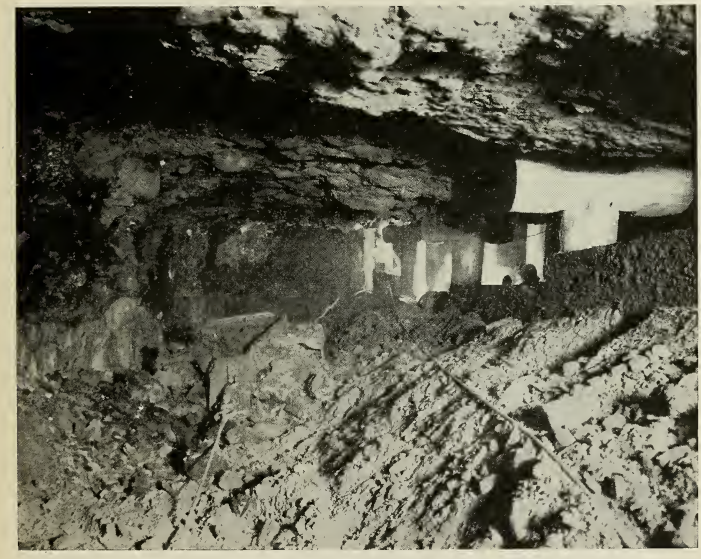

FIG. 13. Ruby Mine, timbering. Slusher scraper at left.
Photo by courtesy L. L. Huelsdonk

Most of the tailing is stacked on the property by means of a belt conveyor.

The second serpentine belt mentioned above is 490 ft. wide, then the workings pass into the Blue Canyon slate, which is the bedrock of the channel being worked. On the contact of the second serpentine belt and the Blue Canyon formation is a fault called the Independence, on which is a 6-ft. quartz vein. Another quartz vein 4 ft. in width was cut 110 ft. farther ahead in the adit in the Blue Canyon formation. A third vein known as the Wolf vein strikes north and dips 65° W. It is 6 inches to 12 ft. in width. This vein was worked in the years 1935, 1936, and 1937 to a depth of 200 ft. below the main adit level.

Drifts were run north on the 200-ft. level for 600 ft. and the ore was stoped through to the main adit level. This work on the quartz vein had been discontinued and the workings are now full of water. Ore was treated in a stamp mill of 30 tons daily capacity, and treatment was amalgamation on plates followed by tables and flotation. The quartz averaged $5.80 per ton in the mill but additional gold was recovered as high-grade. This vein is in the Tightner formation and was found at a distance of 2120 ft. from the portal of the main adit.

Camp facilities are provided for a crew of 40 men, and the property is well equipped with repair shops, drill sharpeners, air compressors, and other modern machinery. Electric power is supplied by Pacific Gas and Electric Company.

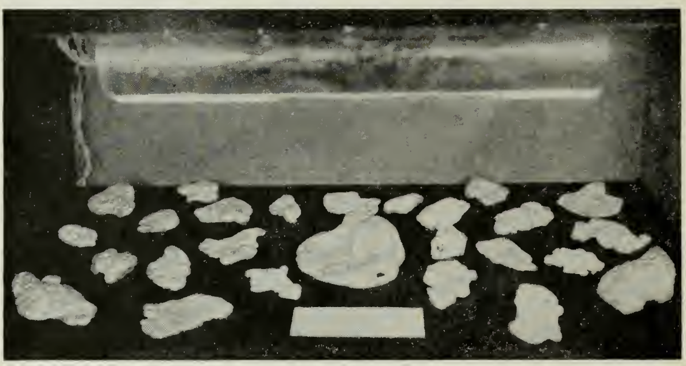

FIG. 14. Gold Nuggets, value $7,000, from the Ruby Mine. Mined in 1938 and displayed at the State Fair. *Photo by Walter W. Bradley*

Sacred Mount and Butte Saddle Group is in secs. 20, 21, T. 20 N., R. 12 E. This combined group of Sacred Mount and Butte Saddle now consists of 14 claims, 240 acres, of which two claims of the Butte Saddle group are patented. The owner is Mrs. Marie E. Phelan, 2226 Capitol Ave., Sacramento. C. A. Beagle has a lease and option. The No. 2 level of Butte Saddle, 1200 ft. long, mentioned in State Mineralogist's Report XIII, p. 373, is said to have exposed three shoots of ore, of which the first was rich and was 120 ft. long. The level is said to have produced $60,000. Phelan sank a 45-ft. winze and the vein is said to have widened from 6 ft. to 7 ft. The vein strikes N. 80° W. and dips 45° to 50° N. The No. 3 level 250 ft. below the No. 2 has been started, but must be driven an estimated 500 ft. to reach the vein. Five men were at work in the summer of 1941 rebuilding the trails to reach the workings. Plans called for resumption of work in the No. 3 level soon. Elevation of No. 3 level is 7000 ft.

A 900-ft. crosscut on the Sacred Mount reaches a vein striking N. 55° W., dipping 65° NE. It is a stringer zone of 4 ft. to 5 ft. in width associated with a contact of slate and an andesitic or dioritic intrusion. The contact is followed only in a general way and the

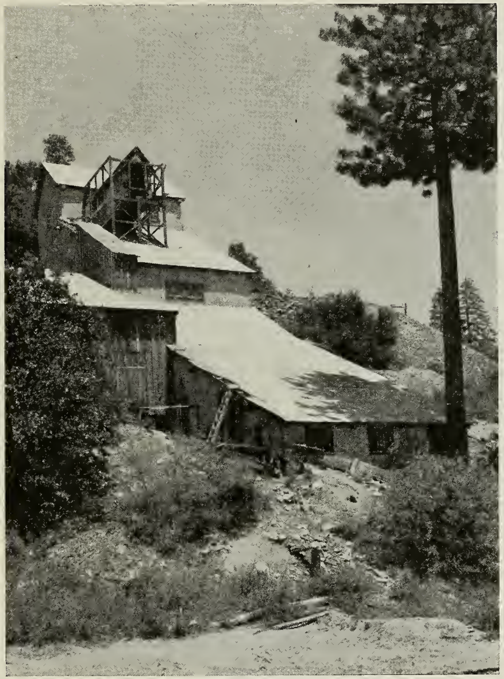

FIG. 15. Mill at Sacred Mount Mine

vein has in places both walls of either formation, sometimes one wall of each. Several hundred feet of drifting have been done in both directions on the vein. Prospecting in the summer of 1941 was in a 40-ft. raise in the west drift. It was planned to drive this for a distance of at least 80 ft. A 7½-inch by 6-inch single-stage compressor with gasoline engine drive was being installed in July, 1941. Equipment also included a 10-stamp mill of 1000-lb. stamps, plates for amalgamation and one Deister table.

Scales Placer Mining Company is in secs 17, 18, T. 20 N., R. 9 E. The following claims are assessed to the company, care of J. J. McCullough, 551 Fifth Avenue, New York City, N. Y.: Cleveland, Sierra, Oversight, Gold Cup, Reservoir, Relocation, Lincoln, Baltimore, Good Hope, Southern, and Fairplay, all patented, a total of 961 acres. The property has recently been reported sold to Shattuck Denn Mining Company, Thomas Bardon, president, 120 Broadway, New York City, N. Y. Property was not in operation when visited in August 1941.

Extensive hydraulic mining done here has been described in older reports under the headings of *Cleveland* and *Neocene Placer Mining Company.* References to these are contained in the accompanying table of mines.

Sierra Buttes Mine in secs. 6, 7, 19, 20, 28, 29, T. 20 N., R. 12 E., and sec. 31, T. 21 N., R. 12 E., at Sierra City, has been the largest single producer of gold in Sierra County, being credited with a production of $15,000,000 to $17,000,000 according to Logan.[10] The property is assessed to E. A. Hayes and J. O. Hayes, San Jose.

About 1932 a rod mill was installed at the No. 6 level of this property with treatment of ore by amalgamation on plates. Later a Deister table was added. The capacity was 30 tons per day. This equipment is still on the property and there is also an 8 to 10-machine compressor and an electric generator at the No. 9 level. The mill was operated off and on for about three years. Some work was done up to about 1938 but the property is now idle and most of the adits can not be entered on account of caving. The property has been worked entirely through adits and no sinking has been done below the No. 9. Local residents believe that the property offers good prospects below the No. 9 level.

Sierra Buttes Tailing Company has been treating tailing at this mine, and in 1940 treated 1311 tons by cyanide leaching and gravity concentration and recovered 95 ounces of gold and 28 ounces of silver in bullion, and 20 tons of concentrate containing 146 ounces of gold and 46 ounces of silver. This operation was being continued in the summer of 1941.

Sixteen to One Mine, the principal gold producer of Sierra County, is in secs. 3, 4, T. 18 N., R. 10 E., and sec. 34, T. 19 N., R. 10 E., and is assessed to Original Sixteen-to-One Mine, Inc., 1611 Russ Building, San Francisco. C. A. Bennett is superintendent at Alleghany, and F. A. Austin is engineer. The property now includes claims formerly held by Twenty-one and Tightner mines.

The outstanding feature of this mine is the production of gold largely from small shoots of high-grade ore. The richest ore may carry $50 in gold to a pound of ore, and single shoots may yield $200,000 to $1,000,000. One lot of 80 pounds yielded $5,000, and a chunk weighing 160 lbs. netted $28,000.

The vein, which strikes N. 30° W. in the southern part of the mine, has most of its apex beneath a lava capping. The vein was discovered during placer operations, but little attention was paid to it for many years. The first high-grade was discovered in 1907 by H. L. Johnson on Tightner ground. In Tightner workings the strike is about north. The dip varies greatly, from less than 20° to 60°, but over most of the productive part of the mine the dip is between 25° and 30° E. The vein follows a reverse fault on which the amount of movement is thought to have been 300 ft. to 900 ft. The quartz filling reaches a maximum thickness of 50 ft., but the best ore seems to be found where the thickness is 5 ft. to 15 ft. No criterion has yet been found by means of which the positions of high-grade shoots can be determined in

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[10] Logan, C. A., Sierra County: State Mineralogist's Report XXV, p. 170, 1929.

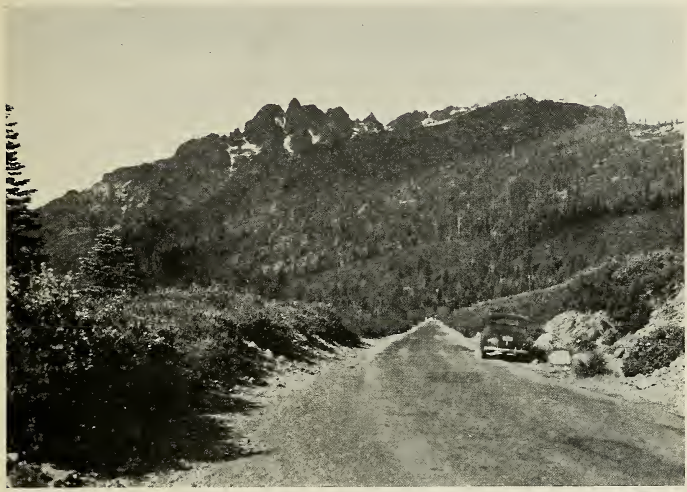

FIG. 16. Sierra Buttes, elevation 8615 ft.

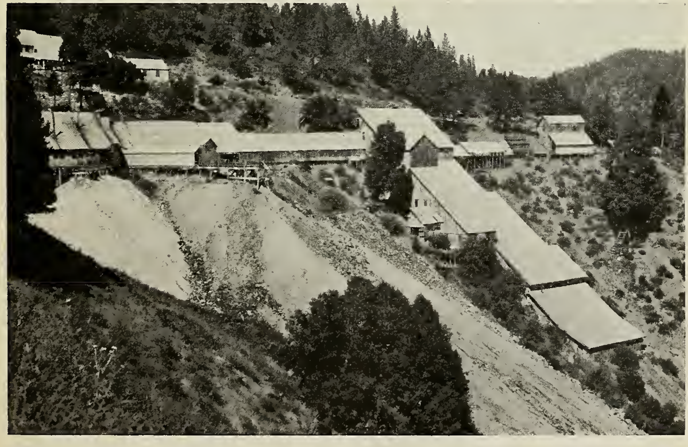

FIG. 17. Mill at Sixteen to One Mine

advance of development work. Hence discovery of shoots is made by cutting the vein into small blocks by means of a large amount of development work. The Tightner formation, here consisting of hornblende schist, forms the walls of the vein. The Kanaka formation has been found on the footwall on upper levels only. These formations are described above in the general section on geology.

The Tightner shaft is the main working shaft and it has been driven to the 3000-ft. level. The main Tightner shaft was driven only to the 2100-ft. level at 3200 ft. elevation for the reason that the hoist would not reach any lower. The lower part of the shaft was sunk independently and at a steeper angle below the horizontal. The upper part of the shaft is driven at an angle of about 35° below horizontal and the lower part is driven at an angle of 60° below horizontal. The reason for this is that a fault dropped the vein on the lower levels. The shaft passed through the vein at the 2700-ft. level, and to reach the vein at lower levels crosscuts must be driven to the east. These conditions are shown in U. S. Geol. Survey Prof. Paper 172, Plate 10, section CC', but the elevation of the shaft is not shown. The 2400-ft. level is the lowest working level at the present time, but water is kept below the 2700-ft. level. The bottom is at a depth of 3000 ft.

To reach the mill, all ore passes through the Sixteen-to-One No. 2 adit level, and no levels above this are in use. At a distance of 300 ft. from the portal of this adit is a two-compartment winze, called the Sixteen-to-One shaft, in and near the vein, bottoming at the 1300-ft. level. A connection is made with the Tightner shaft roughly 1500 ft. to the north at the 250-ft level, another at the 800-ft. level, which is the old Twenty-one adit level, and which is at the level of Kanaka Creek, and is the main drain tunnel. Other main connections between Sixteen-to-One and Tightner are maintained on the 1000-ft., 1100-ft., and 1300-ft. levels.

Half of the tonnage for the mill comes from the Tightner shaft levels above the 1800. This ore must be hoisted the last 250 ft. in the Sixteen-to-One shaft. The other half of the mill tonnage is hoisted from the Sixteen-to-One 1300-ft. level. To avoid tramming ore from the south end of the mine north to the Tightner shaft and then south again to the Sixteen-to-One shaft on the 250-ft. level, a new winze has been sunk from the 1300-ft. level of the Sixteen-to-One shaft. The vein is steeper here, having a dip of 50°. This new winze is 1500 ft. south of the Tightner shaft and is parallel to the Tightner. It is equipped with a 100-hp. single-drum hoist and $1\frac{1}{2}$-ton skip, speed 500 ft. per min. The Sixteen-to-One shaft has a 75-hp. single-drum hoist handling $1\frac{1}{3}$ tons of live load at the speed of 450 ft. per min. The main Tightner shaft is equipped with a double-drum hoist with $2\frac{1}{2}$ ton skip running at 600 ft. per min. to the 2100-ft. level. The sinking to the 3000-ft. level was done with a 50-hp. single-drum hoist.

The mine continues to produce most of its gold from high-grade ore, and 70 per cent of the work in the mine is what would ordinarily be called development work. Drifts are run along the footwall and raises are put up not less than 200 ft. apart on the footwall. Wherever prospects of free gold are found, raises are also driven in or near these prospects. For economical mining it has been determined that levels should not be more than 200 ft. apart on the dip of the vein. Shoveling from the stopes is done with slusher scrapers, double-drum tuggers, of 7½ hp., both air and electric. Chutes are equipped with only a lip, no storage capacity, and slusher hoists are mounted on the opposite side of the drifts in front of these chute lips. Thus the broken ore is dragged by the scrapers directly into the car. Scrapers used are 24 inches to 32 inches wide.

No quartz is put on the dump, but all broken quartz is milled. Daily tonnage is 120, and the cost of putting this broken quartz through the mill was reduced to 79 cents per ton for the year 1939 and 75 cents per ton for the year 1940. Total cost of mining, milling, and development work is $6.50 to $7 per ton of ore. The method of milling has been revised, and plates for amalgamation and corduroy are no longer used. Ore is ground in a ball mill running at 26 rpm. This is the same mill described in State Mineralogist's Report XXV, but it has been speeded up a little. It discharges onto a screen with rectangular openings of 0.29 inch in width and ¾ inch in length. Hungarian riffles have been replaced by hydraulic pulsating traps actuated by Richards pulsating valves at the rate of 360 pulsations per minute. Oversize passes through two more hydraulic traps on its way back to the ball mill. Then it goes over an 8-mesh pulsating screen from which oversize goes back to the mill. Undersize goes to a Deister Overstrom sand rougher table. Overflow from the classifier (minus 30 mesh) goes to a Deister Overstrom fine rougher table. Tailing is made by both of these rougher tables. Mixed concentrate and middling are recleaned, those from the sand rougher table on a Deister Overstrom and those from the fine rougher table on a Wilfley. Concentrate from both finishing tables is given a second cleaning each day by pumping back over a Deister Overstrom table. A surge tank is used to accumulate the flow of concentrate from the rougher tables. About 2 to 3 hours are required for this recleaning. A narrow band of very rich concentrate is recovered and this is amalgamated in a Berdan pan. Five hydraulic traps are cleaned each day also, and the product is amalgamated in a Berdan pan. The product of the traps and the recleaned table concentrate are kept separate in the treatment in the Berdan pan. The trap concentrate is easy to amalgamate and yields more than 95% of its gold to amalgamation. The table concentrate yields 55% to 60%. Concentrate from the Berdan pan after amalgamation is added to second-grade concentrate from the recleaning table and shipped to a smelter. Only about 20 tons per month of this concentrate worth $150 per ton is shipped. The entire returns from the mill amount to only one-third of the total production of the property. The other two-thirds of the production comes from high-grade ore, which is amalgamated in two Berdan pans, and which yields about 99% of its gold to amalgamation. Tailing from this operation is shipped to the smelter. The total number of men employed is 95, of whom about 65 work underground.

Thousand-and-One Mine is an old drift property in secs. 23, 24, 25, 26, T. 20 N., R. 12 E., high on the mountain above the Pride mine. The property has been relocated as the Sundown and Sundown Extension, 320 acres, by Marion Doss, 1612 Morton Street, Alameda, and Arthur E. Doss, Martinez. About 200 ft. of development work has been done in the last two years and the property was worked steadily in 1937 and 1938 by two men who had a lease. The mine was idle and the road had not yet been opened on July 12, 1941. Old workings are described in State Mineralogist's Report XXV, p. 199.

Union Hill is in sec. 18, T. 20 N., R. 9 E. A patented claim of this name is assessed to Neocene Placer Mining Company, C. P. Gardham, secretary, 944 Pine Grove Avenue, Los Angeles. The mine has recently been leased to Melvin Etter, Strawberry Valley, Yuba County, but very little mining has been done. The property is located a mile west of Scales.

Virginia and Lincoln are in sec. 5, T. 21 N., R. 10 E., near the old town of Potosi. A few years ago this mine was operated for a period of two years in the driving of a bedrock tunnel. The gravel channel was struck and an area of 8 ft. by 15 ft. is said to have yielded $300 in gold. However, very little gravel was mined and the mine has been idle for several years.

Waterfall Placer (Rocky Bar), owned by Mrs. Marie E. Phelan, 2226 Capitol Avenue, Sacramento, is in secs. 27, 28, T. 20 N., R. 12 E., near Sierra City. This is a property of 100 acres covering the river channel of South Fork of North Fork of Yuba River. An effort has been made to work it by means of diverting the river through 600 ft. of 4-ft. by 4-ft. flume, but the dam has been washed out and the property is idle.

White Bear Mine is in secs. 9, 16, T. 20 N., R. 10 E., four miles by steep mountain road above Downieville. The owner is White Bear Mining Company, Richard Belcher, secretary, Marysville. Property is leased to George R. Costa and R. Daneri, Downieville, and E. C. Willis, Hayward. Costa and Daneri started work in August, 1939, at which time they put up new buildings to house a shop and compressor; also living quarters. They cleaned out an old tunnel called the Dutch tunnel which had been driven 1400 ft. in a direction N. 75° E. Formations penetrated were as follows: 800 ft. of serpentine, 300 ft. of diorite, 300 ft. more of serpentine, then diorite. At the 1400 ft. point the adit strikes an intervolcanic channel filled largely by a volcanic mudflow. This has been tapped at various points and it carries a little washed gravel and, in places, considerable gold. In one place a layer 2 ft. thick and 4 ft. to 5 ft. wide is stated to have carried as much as 3½ oz. to 5½ oz. of gold per pan for about 10 pans on the bedrock. At this same place an area 15 ft. long and 5 ft. wide is stated to have produced $1,500.

The property is equipped with a 220-cu. ft. portable type compressor driven by a gasoline engine. Washing of the gravel is done with mine-water stored in a 1200-gallon tank near the portal of the adit. Water is turned from a hydraulic nozzle into the storage bin and the gold is recovered on riffles.

Chrome ore was formerly produced here, and the property is mentioned above under the heading of chromium.

IRON ORE

Magnetite occurs in northern Sierra County in the vicinity of Spencer Lakes and Lake Hawley. The chain of deposits is indicated by small outcrops. Baron Richthofen, and later James D. Hague and

Clarence King, described the deposits over 65 years ago and great hope was held for the development of an iron-mining industry there, but nothing resulted.

Sierra Iron Company, San Francisco, owns patented mining claims covering a length of 9900 feet and a width of one-fourth mile including most of the magnetite outcrops mentioned, in secs. 11, 14, and 23, T. 21 N., R. 11 E., at an elevation of 6700 feet. Johnsville, Plumas County, the nearest town, is 5½ miles north in an airline and Blairsden, on the Western Pacific Railway, is 12 miles distant.

Hague and King estimated the aggregate amount of ore in sight as not less than 350,000 tons. Some of the smaller bodies of ore are fine-grained and high grade and contain up to 70% iron, but there is only about 5000 tons of such ore, according to C. Erb Wuensch, who made a report several years ago. The largest outcrop, lying 1000 feet southeast of Lake Hawley, is 200 feet long by 150 feet wide and if it extends to a depth of 75 feet would contain about 320,000 tons according to Wuensch's estimate. This he said averages 37% iron and 43% insoluble of which 26% is silica. Other small lenses nearby contain about 10,000 tons of similar grade.

LIMESTONE AND MARBLE

Dolomitic limestone and marble occur abundantly in the Calaveras formation (Carboniferous) in Sierra County. These deposits are found as a series of disconnected lenses running west of north from the Nevada County line past Sierra City near the eastern border of the Calaveras rocks and into Plumas County. The largest body of the limestone so far mapped is about midway between Downieville and Sierra City, extending for nearly two miles northwest from the main road, and having a maximum width of nearly one-half mile. The magnesia content of samples from some of these deposits was 10% and 19½% according to analyses by the U. S. Geological Survey.

The most accessible bodies of the limestone are:

(1) Three miles northeast and east of Downieville, in secs. 19, 30, and 32, T. 20 N., R. 11 E.

(2) The large deposit mentioned above, is in W½ sec. 27, T. 20 N., R. 11 E.

(3) Smaller lenses north and northeast of Loganville in secs. 29, 30, and 32, T. 20 N., R. 12 E.

Lime from the first and last mentioned localities has been burned and used locally in past years, but there is no present operation.

SOAPSTONE

Blocks of soapstone were quarried 50 years ago at the Alaska Mine near Pike City and were used at the mine for hoist foundations and around the furnaces.

STONE INDUSTRY

The stone industry of the county is confined to the utilization of sand, gravel and rock for highway construction. There are no commercial producers of these in the county.

TABLE OF MINES AND PROSPECTS, SIERRA COUNTY, WITH REFERENCES TO REPORTS OF STATE MINERALOGIST

Name	Kind of mine[1]	Section	Town-ship	Range[4]	Remarks[2] (Location or ownership)	References to Reports of State Mineralogist[3]
Adelaide	Q	24	21	12	Adelaide Gold Mng. & Mg. Co., Sierra City	XI, pp. 400-401; XIII, p. 371; XVI, p. 75
Agate	P	13	21	12		
Alaska	Q	5, 8	18	9	Sierra Alaska Mining Co.;[5] Robinson, Price & McDonald, Financial Center Bldg., Oakland	VI, pt. 2, pp. 58-59; XII, p. 261; XIII, p. 371; XVI, pp. 118-119; XXXI, p. 3. See text this report
Albany Cons. Gp.	Q	5, 6	18	10	Martin White, Table Rock	XVI, p. 75
Alhambra	Q					See Comet—Sovereign
Alhambra Gp.	Q	10	21	10	James S. Freeborough, Hartington-Buxton, Derbyshire, England	XVI, p. 75
Alpha	Q				Alpha Gold Mng. Corp., 100 E. Union St., Pasadena	
Alta						U.S.G.S. Prof. Paper 172, pp. 100-101
Alturas	P	11, 14 15, 21 22, 23	21	9	Maschella, San Francisco	XI, p. 332; XII, p. 261; XIII, p. 371; XVI, p. 134
American Exchange & Buffalo Gp.	Q	12, 13	20	11	Geo. G. Morrison, Sierra City	VIII, p. 580; XIII, p. 371; XVI, p. 76
American Flag	Q	32	19	9	S. E. Martin, Box 57, Klamath Falls, Ore.; J. P. O'Brien, c/o H. Ward Davison, 833 Market St., San Francisco; James Grimes, 858 Walker Ave., Oakland	XVI, p. 77
American Hill	P	28	19	11	Dos Pesos Estate, New York	XVI, p. 66
American Mng. & Dev. Co.	P	14, 15	19	9	American Mng. & Dev. Co.	XVI, p. 134
Amethyst	Q					U.S.G.S. Prof. Paper 172, p. 94-95
Andy Fitz Mng. & Mg. Co.	Q	17	19	10	Andy Fitz Mng. & Mg. Co., 512 Amer. Bank Bldg., 1540 San Pablo Ave., Oakland	XVI, p. 77
Ante Up	Q	17	19	10		See Brush Creek
Antlered Crest	P					XVI, p. 134
Apple & Grant	Q					See Grant & Apple
Arcade	Q					U.S.G.S. Prof. Paper 172, p. 128-129
Argentine, Never Sweat & Germania						See Wide Awake
Ariel	P		20	9	Mrs. J. E. Westall, et al., Sierra City	
Ariola & Daneri Gp.	Q	28, 34	20	10		
Arizona, et al.	P				Hugh McCormick, Downieville	XVII, p. 476; XXV, p. 186
Associated	P	17	20	10	F. P. Morrill, 1538 Henry St., Berkeley	See Hilo
Associated Mines, Inc.	P					See Blue Gravel Mines, Cons.
Atom Gp.	Q	39	19	9	C. W. & Chas. Turner, Camptonville, H. Rabe & C. W. Turner, lessees	XII, p. 261; XVI, p. 77
Australia	Q	34, 35	20	10	Mrs. Marie E. Phelan, 2226 Capitol Ave., Sacramento	See text this report
Badger Hill	P	35	20	10	Jensen, Downieville	XVI, p. 31
Bald Mountain	P	15, 21 22, 27 28, 29	19	10	Heintzen Estate & N. E. McGregor, Downieville	IX, pp. 120-121; XVI, pp. 31-33; Bull. 92, p. 126; U.S.G.S. Prof. Paper 73, p. 142; U.S.G.S. Prof. Paper 172, p. 25. See text this report

Bald Mountain Ext.	P	22, 23	19	10	Bald Mtn. Ext. Gold Mng. Co., Downieville, John Costa, Pres.	VIII, pp. 580-581; XI, pp. 408-409; XII, p. 261-262; XIII, p. 371; XVI, p. 33
Bald Top	P	27	20	9	J. M. McMahon, Supt. for Co.	XXV, p. 186-187
Balsam Flat	P	2	18	10	Capt. Morrill, Alleghany	XVI, p. 34
Bank Mining Co.	Q	1	18	9	Bank Mng. Co., 834 Prudential Bldg., Buffalo, N. Y.	XVI, p. 77
Bannister	Q	2	19	10	Luke Bannister	XVI, p. 78
Banquet	Q					See Edwards Gp.
Bella Union Cons.	P	34 3	21 20	9 9	Mrs. J. E. Westall, Sierra City	XVI, p. 78; XX, p. 365; XXV, pp. 187-188
Bellevue	P	19, 25 26, 30 36	22	9	Bellevue Mng. Co., R. H. Kingdon, Agt., La Porte	XVI, p. 34
Belmont	Q	35	19	10	Mrs. L. C. Harden & Peter Flowers	XVII, p. 471; XVIII, p. 502; U.S.G.S. Prof. Paper 172, pp. 122-123
Bessler	Q	26	20	10	L. & T. Bessler, Downieville	XVI, p. 78; XVII, p. 474; XX, p. 18; XXV, p. 159. See text this report
Big Avalanche Gp.	Q	5, 6 31, 32	19 20	12 12	Big Avalanche Mng. Co., Inc., S. A. Snell, Secy., 170 6th St., San Francisco	
Big Channel Mng. Co.	P					XXV, p. 187
Bigelow	Q	28	20	12	May E. Goyne,[5] 507 Nevada St., Nevada City	XI, p. 413; XII, p. 262; XVI, p. 78; XVIII, p. 737; XXV, pp. 159-160. See text this report
Big Flat	P	29	20	10	W. W. Casserly, Goodyears Bar	
Black Bear	P	4, 9	20	10	H. S. Tibbey, et al., Downieville	See Telegraph (quartz)
Black Jack	Q	16	19	11	Deforest Bros., 30 Broad St., New York	XVI, p. 78
Black Warrior	Q	22	20	10	H. J. Gould, Downieville	XVI, p. 78
Blue Bird	Q				H. H. Bates, B. F. Marsh, Sierra City	
Blue Channel Mng. Co.	P				Blue Channel Mng. Co.	XVI, p. 34
Blue Gravel (Bonanza Clm)	P	33 4	21 20	9 9	C. A. Edgar & Wife, O. C. Ermatinger, Scales	
Blue Gravel Mines Cons.	P	3, 4 33, 34	20 21	9 9	Blue Gravel Mines Cons., W. W. Charles, Pres., 1200 S. Hill St., Los Angeles	XXV, p. 187-188. Sec Lucky Gold Hill in text this report
Bolivia	Q	31	20	12	John Avignoni, Sierra City	XVI, p. 79
Bonanza	Q					See Edwards Gp.
Bonanza	Q					See Mountain Mine
Bon Ton Cons.	P	35	21	9	Richard Kingdon, et al., owners. Blue Gravel Mines Cons., lease and option	XXV, pp. 187-188
Boston	P					See Manchester
Boulder Bar	P				A. R. Koehler, La Porte	
Bradley Cons. Gp.	P	28	20	12	Bradley Cons. Gp.	XVI, p. 134
Bradley-Haley	P					See Pride
Brandy City	Cr	1	19	8		XIII, p. 50; Bull. 38, p. 271; Bull. 76, pp. 189, 222
Brandy City	P	6, 7	19	9	Brandy City Mng. Co., Rm. 414, 216 Pine St., San Francisco	XII, p. 262; XIII, p. 372; XVI, pp. 66-67; XVII, p. 478; U.S.G.S. Prof. Paper 73, pp. 100-101
Brown Bear	P	13, 24 18, 19	20 20	9 10	H. Tibbey, et al., Downieville	XVI, p. 34; XVII, p. 476
Bruckerman	P	3	21	10	F. W. & G. A. Bruckerman, 1358 15th Ave., San Francisco	XIII, p. 372

Footnotes are at end of table.

TABLE OF MINES AND PROSPECTS, SIERRA COUNTY, WITH REFERENCES TO REPORTS OF STATE MINERALOGIST—Continued

Name	Kind of mine[1]	Section	Town-ship	Range[4]	Remarks[2] (Location or ownership)	References to Reports of State Mineralogist[3]
Brush Creek	Q	17, 18 19, 20 29, 30	19	10	Alpha Stores, Ltd.,[5] Nevada City	XVIII, p. 502; XX, p. 17; XXV, p. 160; U.S.G.S. Prof. Paper 172, pp. 87-89, 26. See text this report
Buckeye	P	31	19	10	Buckeye Mng. Co., Albert Read, Pres., Alleghany; E. L. Crafts & E. R. Jones	XI, p. 408; XVI, pp. 34-35
Buckeye Cons.	Q	Loganville	District		R. B. Young, Portola	
Buckingham	Q					See Elcy Mine
Buffalo	Q					See American Exchange & Buffalo
Bullion (Colombo)	Q	30	20	12		X, pp. 648-649; XII, p. 263; XVI, pp. 79-80; XXV, p. 162. See Colombo in text this report
Bullion & El Dorado	Q					See El Dorado
Bull of the Woods	Q	24	21	12		XI, p. 401; XIII, p. 373
Bunker Hill	P					See Blue Channel Mng. Co.
Bunker Hill	P	21	22	10	A. H. Brown,[5] et al.	XII, p. 263
Bunker Hill	P	27	21	9	Lloyd & Andrews, Port Wine	XVI, p. 135
Burlington	P	2	19	11	John Freeman, Sierra City	
Burnham Cons.	P	5, 8	21	11	W. T. Burnham	XVI, p. 135
Butcher Ranch	Q	1, 11 12	20	11	M. H. Miller, 2313½ Q St., Sacramento	XIII, p. 373; XVI, p. 80; XXV, p. 160
Butte Saddle	Q	21	20	12	Butte Saddle Gold Mng. Co.,[5] c/o Mrs. Marie E. Phelan, 2226 Capitol Ave., Sacramento	X, p. 653; XI, p. 416; XIII, p. 373. See Sacred Mount in text this report
Caledonia	P	35	20	10	Caledonia Operating Co., Box 158, Downieville	See text this report
Caledonia	P	12	21	9	Est. of M. M. McBride, c/o A. P. Block, 114 Sansome St., San Francisco	XVI, p. 68; XX, p. 366
California Cons.	P	5	21	10	M. McDonnell & Bros., Table Rock	XVI, p. 35; XX, p. 366. See Table Rock
Campbell	P	At Poverty	Point		Ada L. Jones, 2220 Ward St., Berkeley	
Camptonville	Cr.					See Brandy City
Canada Mng. Co.	P	13	21	9	O. F. Caya & Sherman Est.	XX, p. 365
Captain Cook	P	15	21	10		
Carleton	P	3	21	10	Albert Hough, 3723 Woodruff Ave., Oakland	XVI, p. 35
Carmen	P	15	21	12	Edwards Bros.	
Case & Myer	Cr					XVI, p. 29
Cedar & Baltimore	Q	35	19	10	T. Z. Blakeman. Leased 1922 to F. W. Nicholls, Alleghany	XII, p. 263; XVIII, pp. 513-514; U.S.G.S. Prof. Paper 172, pp. 121-122. See Rising Sun
Central	Q					U.S.G.S. Prof. Paper 172, pp. 117-118
Challenge	P	13, 14	21	9	Catherine E. & Harry C. Wahl,[5] 5699 Oak Grove, Oakland	XX, p. 366. See Big Channel Mng. Co. See Pioneer in text this report
Charcoal Ranch	P	36	20	11	L. F. Fournier & J. Burns, Sierra City	
Chinese	P					XIII, p. 374
Chips	Q					See Swastika Mng. Co.

Chrome "F" "N"	Cr	29	19	10	Davis, Bradbury, Dobbie, Forest	XVI, p. 29
City of Six	Q	2	19	10	City of Six Mng. Co., A. E. Hodgkinson, Secy., 302 Lane Mortgage Bldg., Los Angeles, lessee	XVI, p. 81; XVII, p. 474; XVIII, p. 737; XX, p. 18; XXV, p. 161; XXXI, p. 3
Cleveland	Q	4	18	10	A. L. House, 304 Kohl Bldg., San Francisco	X, pp. 650-652; XI, pp. 414-415; XII, p. 263; XIII, p. 374; XVI, p. 81; XXV, pp. 161-162
Cleveland	Q	35	20	11	C. E. Patterson, 638 21st St., Oakland, et al.	XVI, p. 81; XVII, p. 474
Cleveland, et al.	P	17, 18	20	9	L. M. Stiles, Del Norte Hotel, El Paso, Texas	XVI, pp. 72-73; XX, pp. 83, 363; XXV, pp. 188-189; XXXI, p. 4
Clipper Ship	P	7	21	10	Clipper Ship Mng. Co., E. H. Wemple, c/o Judge C. A. Odell, Agt., Richmond	XII, p. 263; XVI, p. 36; XX, p. 366
Cold Spring Gp.	P	12	19	10	W. L. Wilson, Downieville	
Colombo-Bullion	Q	19, 30 24	20 20	12 11		See text this report
Colorado-Yellow Jacket	Q	34	19	10	Yellow Jacket Cons. Gold Mines, Ltd.,[5] Chas. E. Trezona, 525 Security Bldg., Los Angeles	XVI, p. 81; XVIII, pp. 511-512; U.S.G.S. Prof. Paper 172, p. 119. See Osceola Gp.
Columbia Channel	P	12, 13, 14, 15, 20, 21, 22, 28, 29	19	11	Columbia Channel Gold Mng. Co., John C. Newlands, Secy., Sharon Bldg., San Francisco	XVI, p. 36
Comet	P				Catherine E. & Harry C. Wahl,[5] 5699 Oak Grove, Oakland	See Pioneer in text this report
Comet	Q	17	19	11	Sovereign-Comet Gold Mng. Co., F. O. Richardson, Mgr., Downieville	XI, p. 404; XVI, p. 76; XVII, p. 474
Commodore	P	2	19	12	Mrs. Marie Phelan, 2226 Capitol Ave., Sacramento	See text this report
Comrade	P	24	21	10		
Conglomerate	P	13	21	10	T. C. Corlett, Table Rock	
Contact Gp.	Q				Sierra Gold Mng. Co., Geo. Wood, Secy., Rm. 7, Grant Bldg., Richmond	XVIII, p. 502; XX, p. 17
Continental	Q	26	19	10	Continental Mng. Co., B. B. Lewis, Alleghany	U.S.G.S. Prof. Paper 172, p. 124
Cooper Prospect	Q					U.S.G.S. Prof. Paper 172, p. 129
Corotoman	P	28, 29, 32, 33	19	10	Jessie A. Rea, Growers Bank Bldg., San Jose	XVI, p. 37
Craycroft	P	12	20	10	W. H. Spaulding, 14 Sansome St., San Francisco	XII, pp. 263-264; XIII, p. 374; XVI, p. 68
Croesus Gold Mng. & Mg. Co.						See Plumbago
Crowell, E.	P					XXV, p. 189
Crown Point	P				Sinnott & Carmichael, Gibsonville	XIII, pp. 374-375
Davis Motor	P	23	21	9	D. M. Davis, La Porte	See text this report
Dayton Cons. Gp.	Q	36	20	11	S. Stephenson, Sierra City	
Dead River Gp.	P, Q	33, 34	19	10	Stanley Weiland, Scranton, Pa., Dead River Gold Mng. Co., Alleghany	XVIII, pp. 502-503; U.S.G.S. Prof. Paper 172, p. 27, 102; XVI, p. 37; XX, p. 18
Deadwood	P					XXV, p. 190
Deal	P					See Rattlesnake
Deer Gp.	P	31	21	12	E. A. & J. O. Hayes, San Jose	XVI, p. 135
Deer Lake et al.	Q				Mary W. Peck, 1461 Carrol Ave., Los Angeles	
Del Norte & Scotia	Q	4 33	18 19	10 10	E. L. Crafts, Forest	XVI, p. 82
De Luxe	Q				Jesse Darnell, Agt., 132 Cooper Ave., Yuba City	See Granger

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TABLE OF MINES AND PROSPECTS, SIERRA COUNTY, WITH REFERENCES TO REPORTS OF STATE MINERALOGIST—Continued

Name	Kind of mine[1]	Section	Town-ship	Range[4]	Remarks[2] (Location or ownership)	References to Reports of State Mineralogist[3]
Depot Hill	P	19	19	9	J. F. Joubert, Camptonville	XII, p. 264; XIII, p. 375; XVI, p. 69; XVII, p. 478; XXV, p. 189-190; XXXI, p. 4. See text this report
Diadem	Q	28	19	10	Est. of J. M. Harper, R. B. Harper, Admr., 74 New Montgomery St., San Francisco	XVI, p. 82; U.S.G.S. Prof. Paper 172, p. 95
Diana, et al.	P				C. B. Wingate, 321 El Cerrito Ave., Piedmont	
Diana Mng. Co.	P	29	22	10	Diana Mng. Co., Merchants Exchange Bldg., San Francisco	XVI, p. 135
Dickey Exploration Co.	Q					See Oriental
Dixie et al.	Q				H. E. Nieman, Vader, Wash.	
Docile	Q	35	19	10	Edwin E. Smith, 71 1st St., San Francisco	XII, p. 264; XIII, p. 375; XVI, pp. 82-83; XVIII, p. 503; U.S.G.S. Prof. Paper 172, pp. 123-124
Dolly Varden	Q					See Lonesome Pine
Dorris Gp.	Q	29, 31, 32	19	10	R. D. Dorris, Forest	XVI, p. 29
Dragon Fly	P	33	21	11	N. H. Squire & C. J. Simmons, Downieville	XVI, p. 135
Dreadnaught	Q	35	19	10	Evan R. Jones & Owen T. Owen, Forest	XII, p. 264; XVI, p. 83; XVIII, p. 503; U.S.G.S. Prof. Paper 172, p. 122
Dudley	Q	21, 22, 27	20	12	Margaret Dudley, c/o Christine H. Kenyon, Agt., Springville	
Durston Gold Mng. Co.	Q	3, 4	18	10	Durston Gold Mng. Co., 903 Merchants Natl. Bank Bldg., San Francisco	XVI, p. 83
Eagle	P	23	21	9	Liberty heirs & Dr. Hopkins	VIII, p. 579; XI, p. 418; XVI, p. 37; XX, p. 365
Eagle Bird	Q	9	19	11	M. H. Miller, 2313½ Q St., Sacramento, et al.	XXV, pp. 162-163
Eastern Cross Gp.	Q					U.S.G.S. Prof. Paper 172, pp. 120-121
Eastern Star	Q				Bonded to C. A. Jackson	XVI, p. 84; U.S.G.S. Prof. Paper 172, pp. 120-121
Eclipse	Q	34	19	10	Original Sixteen to One Mng. Co., et al.	XIII, p. 375; XVIII, p. 511; U.S.G.S. Prof. Paper 172, pp. 109-111
Eclipse Cons.	Q				Robt. Foster, Latrobe	
Edwards, A. W. Gp.	Q	10, 15	21	12	A. W. Edwards	See Gold Lake
Edwards, F. Gp.	Q	2, 3	18	10	E. Edwards, Alleghany	XVI, p. 79; XVIII, p. 503; XXV, p. 163
Eighty-Nine	Q				Geo. W. Cox, 2955 Claremont Ave., Berkeley	
Eleanor	P					XXV, p. 190
Elcy	Q	9	19	11	Est. of J. L. Buckingham, Downieville; M. S. Hamilton, Plaza Bldg., Oakland, Agt.	XVI, pp. 84-85
El Dorado	Q	34, 35	18	10	Fessler Estate, Alleghany	XI, pp. 407-408; XII, p. 262; XIII, pp. 372-373; XVI, pp. 85-86; XVII, p. 474; XVIII, pp. 503-505; U.S.G.S. Prof. Paper 172, pp. 118-119
Elkton	Q	Head Rock	Creek		J. E. Middagh, Downieville, et al.	
Emerald	Q	9	19	11	D. W. Smith & Wm. Shipsey	XVI, p. 86
Empire	P	19	22	9	E. G. Squire, Willows	
Empire Gp. (Gold Valley)	Q	25, 26	21	11	A. & P. Bachels, Goodyears Bar	XII, p. 265; XIII, pp. 376-377; XVI, p. 86; XXV, p. 163
English-American Gold Mng. Co.	Q	29	19	11	157 E. 81st St., New York, N. Y.	See Pilgrim
Erie	P	23	21	9	Mrs. M. J. France, M.R.A., Marysville, or La Porte	
Erwin	P	17	20	10	Wm. Erwin, Downieville, et al., Chas. Herron, lessee, Downieville	XVI, p. 37

Euclid Gp.	Q	21, 22	20	12	Margaret H. Dudley, 2655 Wakefield Ave., Oakland	XXV, pp. 163-164
Eureka	P	7	20	10	Spaulding, Costa, et al., Downieville	XIII, p. 375. See text this report
Eureka	Q					U.S.G.S. Prof. Paper 172, p. 92
Evans	Cr					XVI, p. 29
Evans (Oak)	Q					U.S.G.S. Prof. Paper 172, p. 92
Excelsior	P	12, 13	21	9	Excelsior Drift Gold Mng. Co., A. E. Goddard,[5] 508 10th St., Sacramento	XII, p. 265; XX, p. 366
Excelsior	P					XI, p. 412
Excelsior Gp.	P	29	9	11	Frank Montre, F. Tanguay & J. Merhan, Forest	XII, pp. 267-268; XIII, p. 378; XVI, p. 38
Excelsior (St. Lawrence & Empire)	P	15	20	10	John Costa, M. A. Costa, Downieville	XI, p. 409; XIII, pp. 375-376; XVI, pp. 69-70
Excelsior & White Bear	P					
Fair Play	P					Part of Cleveland Cons.
Faith	Q	Nr. Howland	Flat		Frank T. Wehrle, 795 Gray St., Oroville	
F. & F. Gp.	Q	28, 29, 30	19	10	Jas. Finan, Forest; O. H. Fuller, Grass Valley	
Feather Fork	P	25, 36	22	10	W. C. Wingate, Downieville	XI, p. 419; XII, pp. 265-266; XIII, p. 376. See Thistle Shaft
Federal	Q	27	19	10	Federal Mng. Co., Nevada City; J. M. Harper, Pres., Fairmont; J. W. O'Neil, Secy., Nevada City	XVI, p. 86; U.S.G.S. Prof. Paper 172, p. 94
Fessler	Q					See El Dorado
Finan	Q					U.S.G.S. Prof. Paper 172, p. 89
Finane	Cr	29	19	10		XVI, p. 29
Finney	Q	35	20	10	Gruss Mng. Co., 353 Kearny St., San Francisco, lessee	XVI, p. 133; XX, p. 18; XXV, p. 164. See text this report
First Chance, et al.	P	On Slate	Creek		C. B. Wingate, c/o R. H. Kingdon, La Porte	
Flanagan	P	22, 30	22	10	Anna E. Flanagan, La Porte	
Fordham Gp.	P				L. H. Fordham, c/o Murphy & Wood, Arkansas Trust Bldg., Hot Springs, Ark.	
Forest & Queen	P					See Forest Queen Mng. Co.
Forest Queen	Q	21	21	12	L. B. Chenoweth, Quincy, et al.	
Forest Queen Mng. Co.	P	23	21	10	Forest Queen Mng. Co., P. L. Carmichael, Pres.; J. K. Wall, Secy.	XVI, p. 38
Four Hills	Q	2, 9 10, 11	21	11	Wm. Acland Hood, Sequoia Apts., Berkeley	XIII, p. 293; XVI, pp. 87-88; XXV, pp. 164-165
Frances D.	Q					U.S.G.S. Prof. Paper 172, p. 101
Fruitvale & E. Oakland	Q					See Andy Fitz
Gabland	Q	7	19	12	Mitchner Mng. Co., Harry Mitchner, San Francisco	XVI, p. 88
Garibaldi	Q	36	21	11		XIII, p. 376
Garnet	P	21	22	10	H. Skinner, Gibsonville	
General Grant	Q	19	18	9	Elam Biggs, Grass Valley	XVI, p. 88
General Sherman	Q					U.S.G.S. Prof. Paper 172, pp. 101-102
Gentile Flat	P	32	20	12	A. Humphreys, et al., 1411 Oak St., South Pasadena	
German Bar	Q					U.S.G.S. Prof. Paper 172, pp. 132-134
Gibraltar	P	7, etc.	21	11	Peter & Jake Kieffer, Downieville	XVI, p. 39; XVII, p. 476; XXV, p. 191. See text this report
Gibsonville	Cr	29	22	10	W. T. Baldwin, Oroville; L. L. Clough, Chamberlin, Quincy	Bull. 76, pp. 189, 222
Gibsonville Cons.	P	16, 17, 19 20, 30	22	10	Gibsonville Cons. Placer Mines, Marsh-Strong Bldg., Los Angeles	
Gibsonville Mng. Co.	P	30	22	10	J. H. McMahon, et al., Gibsonville	See text this report

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Gibsonville Water & Mng. Co.	P	21	22	10	G. N. Cox, Agt., Table Rock	XII, p. 266
Glidden	Q					See Gold Lake
Gold & Silver Mng. Co.	Q					See Minnesota Dev. Gp.
Gold Basis	Q	25	21	11	Gold Basis Mng. & Mg. Co., 1608 Webster St., Oakland	See Willoughby
Gold Bluff	Q	23, 26 2, 3	20 19	10 10	John Rosenfeld's Sons, 1024 Merchants Exchange, San Francisco	VIII, pp. 579-580; XII, p. 266; XIII, p. 376; XVI, p. 110
Gold Bug	Q					U.S.G.S. Prof. Paper 172, p. 94
Gold Canyon	Q	11	18	10	Caroline H. Hill,[5] 1387 Clay St., San Francisco	XVI, pp. 89-90; XVIII, p. 505; XX, p. 17; U.S.G.S. Prof. Paper 172, pp. 134-135
Golden Era	P	18	21	10	Richard Moore	XVI, p. 135
Golden Fraction	Q	4	18	10	E. Carlson, Supt.	XVI, p. 90
Golden Gate						See Brush Creek in text this report
Golden Hope	P	35	19	10	C. E. Mott, Forest	XVI, p. 39
Golden King	Q	35	19	10	Golden King Mng. Co., 118 California St., San Francisco	XI, p. 417; XII, pp. 266-267; XIII, pp. 377-378; XVI, p. 90; XVIII, p. 505; U.S.G.S. Prof. Paper 172, p. 123
Golden Link	Q	On Sawmill	Ridge		J. H. Beckman, 916½ J St., Sacramento	
Golden Scepter	P	22	21	10	G. A. Maxwell, Continental Bldg., San Francisco	
Golden Star	Q	36	20	10		XIII, p. 378
Gold Hill Gp.	P					See Lucky Gold Hill
Gold King	Q	5	18	10	Marie H. Weldon, W. P. Weldon, 620 Shattuck Ave., Taft	XVI, p. 90; XVIII, p. 505
Gold Lake (Glidden or A. W. Edwards Gp.)	Q	15	21	12	Arthur Edwards, Prescott, Ariz.	XI, p. 401; XII, p. 266; XIII, p. 376; XVI, p. 84
Gold Point	Q					See Gray Eagle
Gold Star	P	32, 33	19	10	Gold Star Mines Co., Box 1102, Sacramento	XVI, pp. 40-41; U.S.G.S. Prof. Paper 172, pp. 92-93
Gold Valley	P					See Poverty Hill
Gold Valley	Q					See Empire Gp.
Good Hope	Cr	22	20	10	Myers & Case, Downieville	XVI, p. 29
Goodyear Bar	P				Marion F. Lusk, Downieville	
Goodyear Bar	P	5	19	10	Goodyear Bar Placer Co., c/o Mark Averill, 1608 Webster St., Oakland	XXV, p. 191
Gourley	Q		22	10	Anna B. Gourley, 3035 Deakin St., Berkeley	
Granger	Q				Jess Darnell, Agt., 132 Cooper Ave., Yuba City	XVIII, pp. 505-506
Grant & Apple	Q					IX, p. 38; XI, p. 408; XVIII, p. 508. See Mariposa
Graphic	Q				Thos. Rose, Camptonville	
Gray Eagle	Q				W. A. Derrer, 3540 Downing Ave., Glendale	
Gray Eagle	Q					See Cleveland
Gray Eagle (Gold Point)	Q	28	20	11	Mrs. D. F. Sullivan, Downieville	XVI, p. 91; XXV, pp. 165-166. See text this report
Great Northern	Q	5	20	12	G. Scott, Downieville	See Mountaineer
Green & Farr	Asb	33	20	12		XXV, pp. 154-155. See text this report
Greenwood Mng. & Dev. Co.	P	12	21	9	Greenwood Mng. & Dev. Co., Port Wine	
Grizzly Hill	P	17	19	9	W. A. Hoff, Indian Valley, Camptonville	See text this report

Gruss Mng. Co.						See Finney
Hain Gp.	Q				S. C. Hain, Box 426, Tres Pinos	
Halkyard, et al.	P	29	19	9	Jos. Halkyard & M. G. Calvin, Camptonville, owners. B. F. McNaught, Camptonville or 306 E. Colorado St., Glendale, et al., lessees	XXV, pp. 191-192
Halsey Gp.	P				W. D. O'Brien, 718 Monadnock Bldg., San Francisco	
Hal Taber	P	19	22	9	W. H. Spencer, Hal P. Taber, La Porte	XII, p. 273; XVI, p. 42
Hanley & Co.	P	32, 33	19	10	Mrs. Hanley & Son, Alleghany	XII, p. 267; XIII, p. 378
Hansen Bros.	Q	Head Howard Creek			Hansen Bros., Sierra City	
Happy Camp	P	15	19	10	John Nipp, Goodyears Bar	
Happy-Go-Lucky	P	11	21	10	W. S. Chestain, Table Rock, via La Porte	
Happy Hollow Gp.	P	29	22	10	Catherine M. F. Judge, 935 Jones St., Reno, Nev.	XII, p. 274; XVI, p. 61; XX, p. 365
Hardscrabble	P	3 34	20 21	9 9	Mrs. Alice S. Brown, 2416 McKinley Ave., Berkeley, et al. Option to Blue Gravel Mines Cons.	XVI, p. 70; XX, p. 364; XXV, pp. 187-188
Hartman	Q				Henry Hartman	XVI, p. 91
Hawkeye & Blue Bell Gp.	P					See Excelsior Gp.
Hawkeye & Pittsburg	P					See Winkeye
Hayes	P	31	22	10	Ah Gook, Table Rock	
Hayes Cons.	Q					See King Cons. Gp.
Hayes & Steelman	P					XI, p. 401
Helena	P					See Flanagan
Herkimer & Bunker Hill (Oro Puro)	P	22, 27	21	10	Chas. W. Kitts, 1248 25th Ave., San Francisco	XVI, pp. 42-43
Hidden Nugget	P	14	18	9	Hidden Nugget Placer Mng. Co., 810 Electric Bldg., San Francisco	
Hidden Treasure	P	10	21	10	Chas. F. Bettinger, Table Rock, via La Porte	
High Commission	Q	25, 26	20	10	John A. & Annie Reid, Downieville	XVI, pp. 91-92
Highland	Q				Sierra Highland Mng. Co., 401 Claus Spreckels Bldg., San Francisco	U.S.G.S. Prof. Paper 172, p. 25
Highland Mary	P	24	21	9	Highland Mary Mng. Co., La Porte	
Hilda	P	2, 3 35	19 20	12 12	Hilda Gold Mng. Co., 948 Market St., San Francisco	XVI, p. 70; XVII, pp. 476-477
Hilo	P	17	20	10	Bernhardt Bros., Downieville	XVII, p. 477; XXV, p. 192
Hobby	P	17	19	9	M. W. Hobby, Camptonville	XVI, p. 136
Holloway	P					XIII, p. 378
Homestake	P	14	21	12	Atkinson Bros., Camptonville	XIII, p. 378
Homestake	P	21	22	10	H. Forbes, Gibsonville	
Homestake	Q	9	19	10	Mrs. B. Haskell, Gen. Del., Oakland	XVI, p. 92
Hope	Q					See Minnesota Dev. Gp.
Hughes	Q	35	20	10	Mrs. Ellen Lawrence, et al., Reno, Nevada	See text this report
Hughes & Westfall	P					XIII, pp. 378-379
Humming Bird	Q				W. A. Derrer, 3540 Downing Ave., Glendale	
Hustler	P				C. A. Reid, Bangor	
Ina	Q				Excelsior Drift Gold Mng. Co.	See Excelsior
Independence	P					See Sierra Buttes
Independence	Q					
Independent	Q	12	18	10		
Indian Hill	P	16, 18 19, 20	19	9	Yuba River Power Co., Rm. 725, 225 Bush St., San Francisco	XXV, pp. 192-193. See text this report
Iowa	P	5	20	9	Oakland Bank of Savings, Oakland. Option to Blue Gravel Mines Cons.	XVI, pp. 43-44; XXV, pp. 187-188

Footnotes are at end of table.

TABLE OF MINES AND PROSPECTS, SIERRA COUNTY, WITH REFERENCES TO REPORTS OF STATE MINERALOGIST—Continued

Name	Kind of mine[1]	Section	Town-ship	Range[4]	Remarks[2] (Location or ownership)	References to Reports of State Mineralogist[3]
Iowa Shaft	P					XX, p. 364; U.S.G.S. Prof. Paper 73, p. 109
Irelan	Q	11	18	10	Irelan Mines Co., Maude H. Waldron, 2519 9th Ave., San Francisco	XVI, p. 92; XVIII, pp. 506-507; XX, p. 17; U.S.G.S. Prof. Paper 172, pp. 14, 127-128
Ironsides	Q	20	19	11	H. B. McCormick, W. L. Redding, Downieville; John Mayer, Sierra City	XVI, pp. 93-94
Iroquois	Q					U.S.G.S. Prof. Paper 172, p. 122
Italian	P					XII, p. 268
I. X. L. Gp.	P	33	22	10	Louisa Hayes, 803 Lincoln St., Oroville	
Jackson	P					XII, p. 268
Jim Crow	Q	9	19	11	L. & Thos. Buckingham, Yuba City; G. Powell, Marysville; Mrs. Margaret Ward; Cooley Butler	XVI, p. 94
Joubert	P					See Depot Hill
Jumper & Tippecanoe	Q	1	19	10	John Reid, Downieville	XVI, pp. 94-95
Kanaka	Q	8, 9	18	10	Ambrose Madden, Alleghany	XVII, p. 475; XVIII, p. 507
Kanaka	P	1 6 36 31	18 18 19 19	9 10 8 10	Mark Alling, Southern Hotel, Bakersfield; Ross L. & Ella M. Taylor, et al., Downieville	XVI, pp. 44-45
Kanaka	Q				L. Foss, Downieville	XI, p. 404
Kate Hardy & Derelict	Q	29, 32	19	10	Kate Hardy Mng. Co., 411 B St., Santa Rosa	XVI, pp. 95-97; XVII, p. 475; XVIII, pp. 507-508; XX, p. 17; XXV, p. 166; Pre. Rp. 8, p. 39; U.S.G.S. Bull. 580, p. 181; U.S.G.S. Prof. Paper 172, pp. 89-91. See Brush Creek in text this report
Kenton	Q	4	18	10	Dr. Royal, Pasadena	XVI, p. 97; XVIII, p. 508; XXI, p. 3; U.S.G.S. Prof. Paper 172, pp. 97-98
Kenton Annex	Q				W. H. Rowe, et al., Nevada City	
Kentucky	Q	27	20	12	Emil & Adolph Loeffler, Sierra City	XVI, pp. 97-98; XXV, p. 166. See text this report
Keystone	Q	5, 6 32	19 20	13 12	E. M. Innes, Sierra City; James Davis, Grass Valley	X, pp. 653-654; XI, pp. 403-404; XVI, p. 98; XVIII, p. 737; XXV, pp. 166-167; U.S.G.S. Folio 37
Keystone Gold Mng. Co.	Q	24	19	10	J. R. Powell, Plymouth, Pa.	
King Cons. Gp.	Q	36	19	10	John Hayes, Sierra City	
King Solomon	Q					U.S.G.S. Prof. Paper 172, p. 97
Kinselbach	Q	36	19	10	Langdon Smith, et al., Forest	XVI, p. 98; U.S.G.S. Prof. Paper 172, p. 125
Kirkpatrick	P	15	19	10	Chas. G. Johnson, State Treasurer, Sacramento, et al.	XVI, p. 71; XVII, p. 477; XXV, p. 193; Bull. 92, p. 126. See text this report
Klondike	P	3	19	12	W. W. Turner, Mgr.	XVI, p. 45
Kosmos & Keystone Ext.	P	3, 4	21	10	Henry Hollweg, La Porte	
Ladies	P	5, 8	20	9		Part of Mount Pleasant
Ladies Canyon	P	13	20	11	J. Laveroni, J. & T. Costa, Downieville	XVI, p. 71
Last Chance	P	9	19	10	W. B. & D. E. Ownes, Goodyears Bar	XIII, p. 379
Last Chance	P	32 5	22 21	10 10	T. Donohue, St. Louis, et al.	
Last Resort	P					See Sebastopol

Lawler	Q				R. McIntosh, San Francisco	XII, p. 269
Lincoln	P					Part of Cleveland Cons.
Lincoln Placers	P	31 35, 36	20 20	11 10	Lincoln Placers, Inc., Chas. L. Nichols, 1408 Chapman Bldg., Los Angeles	
Lincoln & Virginia	P	4	21	10	Potosi Mng. Co., H. R. Fowler, Supt.	See Virginia in text this report
Little Grizzly	P	23	21	10	Chas. Kelles, Downieville	
Little John & Klondike	Q					See Gabland
Live Yankee	P					U.S.G.S. Prof. Paper 172, p. 25
Lloyd & Milward	Asb	30 33, 34 3, 4	21 20 19	12 12 12	Carl L. Lloyd,[5] 498 25th St., Oakland; M. S. Milward, Sierra City	See text this report
Loftus Blue Lead Mines Co.	P	31, 32 5, 6, 7 12	22 21 21	10 10 9	E. A. McKanna, 801 Columbia St., South Pasadena; Jas. Kelly, La Porte	XXV, p. 193. See text this report
Lonesome Pine	Q	8	19	11	Homer Gould, Downieville; John Donnelly, Sacramento	XVI, p. 99
Lone Star Gp.	Q	25	21	11	Lone Star Cons. Gold Mng. Co., Mr. Thomas, Grass Valley, Secy.	XI, p. 405; XII, p. 268; XVI, p. 99
Lone Wolf	Q	28	21	12	Mark Smith, Sierra City	See text this report
Lorenzo	Q	26	21	11	P. Lorenzo, Johnsville	
Lost River (Rocky Peak)	P	4 28, 33	19 20	9 9	Mark N. Alling, Southern Hotel, Bakersfield; Emeline A. Alling, Downieville; Geo. F. Taylor, W. I. & Lena A. Redding, et al.	XII, p. 271; XVI, pp. 45-47; U.S.G.S. Prof. Paper 73, p. 111
Lost Treasure	Q	20	19	10	Fred Phippin & Wm. Davies, Forest	XVI, pp. 99-100
Luce & Co.	Cr					See Brandy City
Luckey Larry	Q					U.S.G.S. Prof. Paper 172, pp. 113-114
Lucky Boy	P	In Indian	Creek		M. E. Whittum, Camptonville	
Lucky Dog	P	29	19	10	Frank & Wm. Davies, Forest; Thos. Fitzgerald, J. B. Moulton, E. R. Jones	XII, p. 268; XVI, p. 47
Lucky Gold Hill Co.	P	33, 34 3, 4	21 20	9 9	Ferrard Leicester, Pres., 105 Montgomery St., San Francisco	XII, p. 268; XVI, pp. 39-40; XX, p. 365; XXV, p. 193. See text this report
Lucky Hill	P					See Lucky Gold Hill Co.
Luella	Q	22	21	10	James D. Alexander, Downieville	
Mabel Mertz	P	29, 30	19	11	Forest City Mng. Co., Downieville; H. B. McCormick, Downieville, Secy.	XVI, pp. 47-48
Macchaus	Cr	5	18	10	Henry Macchaus, Alleghany, et al.	XVI, p. 29
Mammoth	Q	2	21	10	Richard Sparling Est., Table Rock; and Mrs. Strand	XVI, p. 101
Mammoth Springs	Q	26	19	10	Mammoth Springs Mng. Co., J. W. McGuire, 2506 Folsom St., San Francisco	XVI, pp. 100-101; U.S.G.S. Prof. Paper 172, p. 125
Mammoth Springs	P	23, 26	19	10	Milton Davis, Forest	XII, pp. 268-269; XIII, p. 379; XVI, pp. 48, 100-101
Manchester	P	21	22	10	Belle C. & Wm. S. Brown, 2103 Van Ness Ave., San Francisco	XVI, p. 48
Manuxman & Bluebell	P					See Scott
Maple Grove	P					XI, p. 408
Marguerite	P	Gibsonville			Stefanno Verenno, 935 Jones St., Reno	
Marguerite	Q	3	20	12	Westall Bros., Sierra City	

Footnotes are at end of table.

TABLE OF MINES AND PROSPECTS, SIERRA COUNTY, WITH REFERENCES TO REPORTS OF STATE MINERALOGIST—Continued

Name	Kind of mine[1]	Section	Township	Range[4]	Remarks[2] (Location or ownership)	References to Reports of State Mineralogist[3]
Mariposa	Q	2, 3 34	18 19	10 10	Mariposa Mines Ass., H. Fellenz, Secy., Theresa, Wis.	XIII, p. 379; XVI, p. 101; XVII, p. 475; XVIII, pp. 508-509; U.S.G.S. Prof. Paper 172, pp. 20-21
Martine	Q					See Keystone
Maryland	Q					U.S.G.S. Prof. Paper 172, p. 126
Marysville & Nevada Water & Power Co.	P					XVII, p. 478
Mascot	Q					See Sovereign
Mayday & Undine	P	13, 14, 24	21	12	H. H. Meyer & Estates of Jas. McGregor & E. L. Case, Downieville	XVI, pp. 71-72
Mayflower	Q					U.S.G.S. Prof. Paper 172, p. 117
McCullough Ranch	P	7, 18	20	11	Est. of Joseph J. McCullough, North San Juan	See text this report
Mercer & Salinas	Q					X, pp. 649-650; XI, pp. 413-414
Mexican Gp.	Q	25, 26	20	10	C. J. York, Downieville	XVI, p. 102
Michigan	P	20	22	10	L. L. Clough, Quincy; Lois McDaniel, 815 7th St., Marysville	
Midas	P	5	21	10	C. W. Cox, Table Rock	XI, p. 412
Middle Yuba	P	15, 16, 20 21, 22	18	9	Poorman & Hastings, 1724 Santa Clara Ave., Alameda	XVI, p. 136
Milton	Cr	4 (?)	19	12	R. C. Zaring, Downieville	See text this report
Mineral Mountain	Q	10, 11 14, 15	19	10	M. C. Mitchell, c/o California Cotton Mills, Oakland	
Miner's Home	P	5	21	10	Howland Flat Mines Co., c/o C. L. Faulck, Woodleaf	XVI, pp. 48-50; XX, p. 366
Minnesota Dev. Gp.	Q	2	18	10	Minnesota Dev. Co., J. O. Jones, Forest, Supt.	XIII, pp. 379-380
Minnie D	Q	34	19	10	Albert Holm, Alleghany	XVI, p. 103; U.S.G.S. Prof. Paper 172, pp. 35, 113-114
Monarch	Q	18, 19	20	12	J. H. & F. M. Lee, Sierra City	XVI, pp. 103-104; XVII, p. 475; XXV, p. 167
Monroe Cons. Gp.	Q	35	19	10	Monroe Cons. Quartz Mng. Co.	XVI, p. 104
Monte Carlo	P	26	21	10	A. Lavezzola, Steve Dondero & Poggi, Downieville	XVI, p. 50; XVII, p. 477; XXV, pp. 193-194
Monte Cristo	P					See West Point-Monte Cristo
Monterey	P					See Lost River
Montpelier	Q	26	20	10	Mrs. Emma Hughes, Reno, et al., J. R. Stark, Downieville, lessee	XXV, p. 167
Montrose Development Co.	P					XXV, p. 194
Moonshine	Q				Geo. W. Hallock, Alleghany	XVI, p. 103; XVIII, p. 510
Morning Glory	Q	34	19	10	Est. of Martin & Christina Rohrig, Alleghany	XVI, p. 105; XVIII, pp. 509-510; U.S.G.S. Prof. Paper 172, pp. 109-112
Morning Sun	Q	35	19	10	F. W. Nicholls, Alleghany	XVIII, p. 510
Morristown & Angora Gp.	P	24 30	21 21	9 10	A. Harris, La Porte	XVI, p. 50
Motor Gravel	P					See Davis Motor
Mott (Mt. Vernon)	P	12	19	10	Mott & Morrison, Forest; Harlan, San Jose	XVI, p. 51
Mott & Brady Gp.	P	11	19	10	C. E. Mott, Forest	XVI, p. 51
Mountain (Bonanza)	Q	16	20	12	F. R. Wehe, trustee, 74 New Montgomery St., San Francisco	X, pp. 647-648; XI, p. 402; XII, p. 269; XIII, pp. 371-372; XVI, p. 105

Mountain Boy	P	At Bunker	Hill		Frank Prosser, Martinez	
Mountaineer	Q	5	20	12	G. Scott, Downieville	XIII, p. 380; XXV, p. 166
Mountaineer	Q	24	21	12	Harry Morris	
Mountain House	P	18, 19, 30 25	19 19	10 9	W. J. Belcher, W. E. Casserly, G. W. Voelzel & Mark Alling	XVI, pp. 51-52
Mountain Ledge	Q					See Mountain
Mountain Lion	P				J. H. Williams, North Columbia	
Mountain View	P	24	19	10	Wayland, Alleghany	XVI, p. 52
Mountain View Cons. Gp.	P	30	21	10	Messery & Shield, La Porte	
Mountain View	Q					U.S.G.S. Prof. Paper 172, pp. 125-126
Mount Alta	P	33	19	9	Mrs. R. M. St. Claire, 421 5th St., Marysville; C. N. Chatfield, Pike	XVI, p. 53; XVII, p. 477; XXV, p. 194
Mount Filmore Cons. Gp.	Q	34	22	10	Frank Bonnec, La Porte; A. D. Post, Agt., La Porte	XII, p. 269; XIII, p. 380; XVI, p. 105
Mount Moriah	Q					See Lawler
Mount Pleasant	P	5, 8, 9	20	9	Kate Donohue, 396 Hayes St., San Francisco	XX, p. 364; XXV, p. 194
Mount Rainier	P	8, 9	18	10	Jos. J. McCullough, North San Juan	
Mount Vernon & Mott Tunnel Gp. (Pilot)	P	12	19	10	Midway Divide Mng. Co., Leased to Harkins & Maloney	XVI, pp. 52-53; XXV, p. 195
Mugginsville	P	18	20	10	W. A. Morse, Downieville	
Mugwump	P	28, 33	19	10	Mugwump Mines Co., S. L. Bright, San Francisco, A. D. Foote, C. F. Clinch, A. H. Tickell, Grass Valley, et al.	X, pp. 577-578, 643-647; XI, p. 407; XII, p. 275; XIII, p. 384; XVI, pp. 53, 133-134; XVIII, p. 143; XXV, pp. 194-195; Pre. Rep. 8, p. 39
Myrtle	Q					VIII, p. 579
National, E. & W.	P		20	9	Henry Kingdon,[5] Rt. 2, Box 240, Oroville	See Poverty Hill Properties in text this report
Neocene	P	Lots 62, 63	20	9	Neocene Placer Mng. Co.,[5] C. P. Gardham, Secy., 944 Pine Grove Ave., Los Angeles	XVI, pp. 72-73. See Scales Placer Mng. Co. in text this report
New Council Hill, Alturas Ext., & Fairplay Gp.	P	Lots 48-56 inc.	20	9	A. C. Stiles, 204 Mills Bldg., El Paso, Tex.; F. R. Wehe, 74 New Montgomery St., San Francisco	XVII, p. 478
New Jersey	P	31	19	10	A. Eckhart, 531 Dolores St., San Francisco	XVI, p. 53
New York	P	13, 14, 23 24, 26	21	12	Hugh & Westall Estate, Sierra City	XIII, p. 378; XVI, p. 73
New York	Q	3	21	10	Wm. Schuld, La Porte	XVI, p. 106
Night Hawk	Q				P. T. Turner, La Porte	
North American Cons.	P	30	22	10	North American Cons. Mng. Co., Garden City Bank Bldg., San Jose	
Northern Bell Gp.	Q	31	20	12	L. Rosenfeld, San Francisco; Northern Bell Mng. Co.	X, p. 653
North Fork	Q	21	19	10	North Fork Mng. Co., 1024 Mills Bldg., San Francisco	XIII, p. 380; XVI, pp. 106-107; XX, p. 18; XXV, pp. 167-168; U.S.G.S. Prof. Paper 172, pp. 25, 27, 95-97
North Fork Co.	P					XIII, p. 380. See Wisconsin North Fork
Nuggett Nell	P	4	20	10	Estate of J. McGregor, Downieville, et al.	XVI, p. 53; XVII, p. 477
Oak	Q					See Evans
Oakland	Q	13	21	11	F. A. Gowing	XVI, p. 107
Oasis	Q	4	18	10	Oasis Mng. & R. Co., Thos. H. Allen, Jr., 433 S. Spring St., Los Angeles	
Occidental	P					XVI, p. 53. See Shotgun

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TABLE OF MINES AND PROSPECTS, SIERRA COUNTY, WITH REFERENCES TO REPORTS OF STATE MINERALOGIST—Continued

Name	Kind of mine[1]	Section	Town-ship	Range[4]	Remarks[2] (Location or ownership)	References to Reports of State Mineralogist[3]
Old Colony	P	Nr. Kirkpatrick			C. Tilford, J. Mariott, R. E. Miesse, Lou Schrimpf, lessees	
Old Mexican	Q	9, 10	19	10	Bachels Bros., Goodyears Bar	XXV, p. 168
Omega	P	29	19	10	E. T. O. Cons. Mng. Co., c/o C. H. Spengler, Forest	XVI, p. 137
Ophir	Q					XVIII, pp. 510-511; U.S.G.S. Prof. Paper 172, pp. 110-111
Orient Gp.	P	31, 32	19	9	Orient Gold Placer Mng. Co., Nevada City	XVI, pp. 53-54; XX, p. 18
Oriental	Q	33 4	19 18	10 10	Oriental Mng. Co.,[5] H. B. Drescher, Front and K Sts., Sacramento	XVI, pp. 107-108; XVIII, p. 511; XX, p. 18; XXV, p. 168; XXXI, p. 3; U.S.G.S. Prof. Paper 172, pp. 26, 32, 98-101. See text this report
Oriflame	Q	3	18	10	L. D. Nihell & Jack Langman, Alleghany	XVIII, p. 511; U.S.G.S. Prof. Paper 172, pp. 126-127
Original 16 to 1	Q	3, 4 34	18 19	10 10	Original Sixteen to One Mng. Co.,[5] 1611 Russ Bldg., San Francisco	XVI, pp. 122-124; XVII, p. 475; XVIII, pp. 143, 514-517; XIX, p. 73; XX, pp. 17-18; XXV, pp. 171-172; Pre. Rep. 8, p. 39; U.S.G.S. Bull. 580, p. 175; U.S.G.S. Prof. Paper 172, pp. 31, 33, 35, 38, 54, 106-110. See Sixteen to One in text this report
Oro	Q	35 2	20 19	10 10	Downieville Mng. Co., Chas. Herron, et al., Downieville	XVI, p. 108; XVII, p. 475; XVIII, p. 737
Osceola Gp. (Yellow Jacket)	Q	34	19	10		XI, p. 407; XVI, pp. 108-109; XVIII, pp. 511-512; XXV, p. 173; U.S.G.S. Bull. 580, pp. 173-174; U.S.G.S. Prof. Paper 172, pp. 78, 79, 114-115; 119-120. See Colorado-Yellow Jacket
Ostego	Q	7	20	11	H. L. Valkenberg,[5] et al., Downieville	
Oxford	Q, Cr.	22, 23 26, 27	20	10	Oxford Quartz Mng. Co., A. J. Just, Secy., Downieville	XII, pp. 269-270; XVI, pp. 109-110; XX, p. 18. See text this report
Pacific Gp.	P	18	21	10	James Jones, La Porte; Will F. Sewering, 1613 Grove St., Berkeley. Central Cons. Co., Oakland, lessee	XVI, p. 54; XXV, p. 195
Pacific Alta Gp.		12	21	9	D. Conlan, St. Louis, via La Porte	XIII, p. 381
Panama	Q					U.S.G.S. Prof. Paper 172, p. 115
Paramount	P					See Pride
Pat Young	Q	29	20	12		XVI, p. 111
Pennsylvania	P	2	21	10	L. H. Molter, Table Rock	
Pennsylvania	P	32	22	10	John Doherty	XVI, p. 137
Peterson	P	33	20	12	H. Green, I. J. Farr, Sierra City	XXV, p. 195
Phil Doris	P					See Slate Creek
Phoenix	Q	21, 22 28, 29	20	12	Heirs of C. J. Winstead in litigation with heirs of J. W. Kane	X, p. 653; XI, p. 402; XIII, p. 381; XVI, pp. 111-112
Pig Canyon	P	10	20	11	Thompson Bros., Sierra City	

Pilgrim	Q	29	19	11	Dos Pesos Estate, New York	XVI, p. 112; XXV, pp. 168-169
Pilot Peak Gp.	P	20	22	10	Frank & Walter Delahunty, La Porte	
Pine Grove	P					See Hayes
Pioneer	P	13, 14 23, 24	21	9	W. H. Pike,[5] La Porte	XI, p. 412; XII, p. 270; XIII, p. 381; XVI, p. 54; XX, pp. 365-366. See text this report
Pleasant View	P				E. L. Cleveland, 520 Oschner Bldg., Sacramento, et al.	XVI, pp. 54-55; XXV, p. 196
Plumbago	Q	2	18	10	Croesus Gold Mng. & Mg. Co.,[5] 730 5th Ave., New York, N. Y.	XII, p. 270; XIII, p. 381; XVI, pp. 112-113; XVIII, pp. 143, 512-513; XIX, p. 73; XX, p. 18; XXV, p. 169; U.S.G.S. Prof. Paper 172, pp. 26, 29, 36, 54, 129-132
Poker Flat	Cr	16	21	10		See text this report
Poker Flat	P	10	21	10	Carl Bettinger & J. B. Lassiat; Poker Flat Gold Gravel Mng. Co.	XVI, p. 55; XXV, p. 196
Poor Boy	P	32	20	10	W. W. Casserly, Goodyears Bar	XX, p. 365
Poor Boy Cons.	P	34 3	21 20	9 9	John S. Lloyd, et al. Blue Gravel Mines Cons., lease and option	XVI, p. 55; XVII, p. 477; XX, p. 365; XXV, pp. 187-188
Port Wine Cons.	P	13, 14 18	21 21	9 10	Big Channel Mng. Co., H. A. Kluegel, Sacramento	See Big Channel Mng. Co.
Poverty Hill	P	32 5	21 20	9 9	Judson Estate, c/o Seth Mann, 202 Merchants Exchange Bldg., San Francisco	XVI, p. 70; XX, pp. 363-364; XXV, pp. 196-197; U.S.G.S. Prof. Paper 73, p. 100. See text this report
Pride Hydraulic	P	11, 12 13, 14	20	12	Arthur Pride,[5] et al., Sierra City	XXV, p. 197. See text this report
Primrose	Q	11, 13, 14	20	11	Adolph Siebrecht, 206 Judah St., San Francisco; and M. D. Cogley[5]	XXV, p. 169. See text this report
Prospect	Q	2	19	10	Prospect Mng. Co.	XVI, p. 113
Pyro	P	3, 4	21	10	Hunter Gold Mng. Co.	XVI, p. 56
Rainbow	Q	2, 3	18	10	Rainbow Gold Mng. Co., E. L. Gould, Secy., 1007 Sutter St., San Francisco	VIII, p. 578; XI, p. 407; XII, p. 270; XIII, p. 381; XVI, pp. 113-114; XVIII, pp. 143, 513; XX, pp. 17-18; Pre. Rep. 8, p. 39; U.S.G.S. Bull. 580, p. 177; U.S.G.S. Prof. Paper 172, pp. 26, 27, 54, 79, 102-105
Rainbow Extension	Q	3	18	10	San Jose Mng. & Invt. Co., O. A. Harlan, San Jose	XVIII, p. 513; U.S.G.S. Prof. Paper 172, pp. 105-106
Rao	Q	34	19	10	R. T. Garnier, 1735 Mission St., South Pasadena	XVI, p. 114; U.S.G.S. Prof. Paper 172, p. 117
Rattlesnake	P	7, 18	20	11	Ed Deal, Downieville. Natl. Merger Mines Co., lease and option	XVI, p. 56; XXV, pp. 195, 197-198
Red Chief	Q					See Red Ledge
Red Jacket	Q				Thos. Rose, Pike City	XVI, p. 114
Red Ledge	Q	12	18	9	Bank Mng. & Promotion Co., W. H. Barnhart, Pres., Buffalo, N. Y.	XVI, pp. 114-115
Redmayne & McGonigal	Cr					XVI, p. 30
Red Star	P					XI, p. 408
Red Star	Q	27, 34	19	10	Tightner Mines Co., 709 Balboa Bldg., San Francisco	XVIII, p. 519; U.S.G.S. Prof. Paper 172, pp. 115-117
Reese Ravine	P, Q	22	21	10	Reese Ravine Mng. Co., 655 Congress St., Portland, Maine	XII, p. 270

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TABLE OF MINES AND PROSPECTS, SIERRA COUNTY, WITH REFERENCES TO REPORTS OF STATE MINERALOGIST—Continued

Name	Kind of mine[1]	Section	Town-ship	Range[4]	Remarks[2] (Location or ownership)	References to Reports of State Mineralogist[3]
Renaissance	P	3	21	10	Fred Bruckermann, Table Rock, via La Porte	
Republic Gp.	Q	17	19	11	A. B. Jenkins, Tuolumne	XVI, p. 115
Richter, Wm. & Sons	P	16, 17	19	9	Rt. 2, Oroville	See text this report
Riffle	P				Riffle Gold Mng. Co., T. F. Giblin, Box 55, Yuba City	XII, pp. 270-271; XX, p. 366; XXV, p. 187
Riley	P					XVI, p. 56
Rising Sun	Q	35	19	10	F. Morton, San Francisco; Alfred B. Morton, Baltimore, Md.	VIII, p. 579; XI, p. 418; XIII, p. 382; XVI, p. 115; XVIII, pp. 513-514; U.S.G.S. Prof. Paper 172, pp. 121-122
Rocky Bar						See Waterfall
Rocky Peak	P					See Lost River
Roman	Q	3	19	12	Big Avalanche Mng. Co., Inc., 170 6th St., San Francisco	
Roye-Sum	Q					U.S.G.S. Prof. Paper 172, p. 98
Ruby	P	10, 11 14, 15	19	10	C. L. Best, Caterpillar Tractor Co., San Leandro	XI, p. 406; XII, pp. 271-272; XIII, p. 382; XVI, pp. 56-57; Bull. 92, p. 126. See text this report
Russell Hill	P	19	19	9	W. S. Russell, Camptonville	XII, p. 272
Sacred Mount & Butte Saddle	Q	20, 21	20	12	Mrs. Marie E. Phelan, 2226 Capitol Ave., Sacramento	XVI, pp. 115-116; XXV, pp. 160-161. See text this report
Sailor Boy Diggings	P					XII, p. 272
Salinas & Mercer	Q	35	20	11	Ed Freeman, Sierra City	XVI, p. 116
San Lois	Q	6	19	12	Mitchner Mng. Co., & H. Mitchner, San Francisco	XVI, p. 116
Scales Placer Mng. Co.	P	17, 18	20	9	c/o J. J. McCullough,[5] 551 5th Ave., New York	See text this report
Scotia & Alice Cons.	Q					XII, p. 272
Scott	P	2, 3	21	10	Jas. Scott & Bros., P. L. Carmichael & J. C. Poor, Table Rock	XVI, pp. 57-58
Sebastopol	Q	21, 26	21	12		XVI, pp. 116-117
Sebastopol	P	1½ mi. from	Poker	Flat	Reese Ravine Mng. Co., 655 Congress St., Portland, Maine	
Secret Canyon	Q	1	19	10	Geo. Henk	XVI, p. 117
Shamrock Gp.	Q	28, 29	20	12	John C. Mansfield, Sierra City	
Shattuck Denn Mng. Co.						See Scales Placer Mng. Co.
Shaughnessy	Q	32	20	11	Wm. Shaughnessy, Downieville	
Sherman	Q	34 3, 4	19 18	10 9	Bradbury Estate, Mrs. E. J. Jenkins, Seattle, Wash.	XVI, pp. 117-118; U.S.G.S. Bull. 580, p. 175
Shirley	P					See Miner's Home
Shotgun	P				Lillian Gatlin, 1030 Post St., San Francisco	
Sierra	P	5, 6	18	11	Sierra Gold Placer Mng. Co., Winston-Salem, North Carolina	
Sierra Alaska	Q	5, 8	18	9		See Alaska
Sierra Buttes	Q	6, 7, 19 20, 28, 29 31	20 20 21	12 12 12	E. A. & J. O. Hayes,[5] San Jose	VI, pt. 2, pp. 56-57; VIII, pp. 573-577; X, p. 643; XI, pp. 402, 416-417; XII, p. 272; XIII, p. 382; XVI, pp. 119-121; XXV, pp. 169-170. See text this report

Sierra Buttes Tailing Co.						See Sierra Buttes
Sierra Geneva	P	31, 32	19	10	M. W. Davis, et al.	XVI, p. 58
Sierra Gold Mng. Co.	Q	24	20	10		XIII, pp. 382-383
Sierra Homestake	Q, Cu	1	20	12	Myrtle M. Gallinger,[5] Tahoe City	XXV, pp. 170-171. See text this report
Sierra Iron Co.	Fe	11, 14 23	21	11		XVI, p. 138; XXV, p. 211. See text this report
Sierra Phoenix	Q					See Alhambra Gp.
Sierra Poorman	Q	4	20	11	Sierra Poorman Mng. Co., Downieville	XVI, p. 121
Sierra Union	P	12	21	9	J. H. Thomas, Oakland; T. Donohue Estate, San Francisco	
Sixteen to One	Q	3, 4 34	18 19	10 10	Original Sixteen-to-One Mine,[5] Inc., 1611 Russ Bldg., San Francisco	See Original Sixteen to One. Also see text this report
Slate Creek	P	36 31 1, 11	22 22 21	9 10 9	C. A. Reed, Bangor	XIII ,p. 382; XVI, p. 137
Slate Creek Debris Dam Co.	P	31	21	9	J. H. Thomas, Oakland	XVI, p. 137
Slug Canyon Tunnel Co.	Q	3	19	10	L. Copeland, 530 California St., San Francisco	XIII, p. 383
Smith	P	10	20	11	Dan R. Thompson, Sierra City	
Smith & Brundage Gp.	P				Rose Conlan, St. Louis, via La Porte	
Snowden Hill (Watts)	P	11, 14, 15	19	9	C. T. Driscoll, trustee, Mission San Jose, Alameda Co.	See Steamboat
Soldier Boy	P	15	21	10	M. M. Marshall, 655 Congress St., Portland, Maine	
South Fork	P	22, 23, 27	19	10	United Eastern Mng. Co., Los Angeles, lessee	VIII, p. 581; XI, p. 407; XII, pp. 272-273; XIII, p. 383; XVI, pp. 58-59
South Fork Gp.	Q					XVI, p. 124; XXV, pp. 172-173; U.S.G.S. Prof. Paper 172, p. 94
Sovereign	Q	24	20	11	Pacific Coast Real Estate & Investment Co., Monterey, Dr. Roberts, Monterey, Pres.	XVI, p. 125
Sovereign-Comet	Q					See Comet-Sovereign
Spoohn	Q					U.S.G.S. Prof. Paper 172, p. 101
Standard	Q	22	20	10	Standard Mines, R. E. Blevins, Williams	XVI, p. 122
Star	Q					XX, p. 366
St. Charles Hill	P	25, 26	20	9	C. S. Morbio,[5] Call Bldg., San Francisco	XIII, pp. 373-374; XVII, pp. 477-478; XXV, p. 198
Steamboat (Snowden)	P	2	18	10		XII, p. 272; XIII, p. 383; XVI, p. 59; XXV, p. 198
Strand	P					XXV, p. 198
Suffolk	P	24	21	9	J. G. Berryhill; A. D. Post, Agt., La Porte	XII, p. 273; XVI, p. 59; XX, p. 366
Sundown	P	23, 24 25, 26	20	12	Arthur E. Doss,[5] Martinez	See Thousand-and-One
Sunnyside	P	5, 8	21	11	B. L. & Annie Jones, Quincy	XVI, p. 138
Sunset	Q					XII, p. 273; XIII, p. 383
Sunshine	P				D. Sullivan, Downieville, et al.	XVII, p. 477
Swastika Mng. Co.	Q	26, 27	20	12	Swastika Mng. Co., 304 Kohl Bldg., San Francisco	X, pp. 652-653; XI, pp. 402-403; XIII, p. 374; XVI, pp. 125-126
Syndicate	P	5 31, 32	21 22	10 10	Syndicate Hydraulic Mines, Inc., 1119 Guaranty Bldg., Hollywood	
Taber	Q	25	22	9		XII, p. 273; XIII, p. 384
Taber	P					See Hal Taber
Table Rock (California Cons.)	P	5	21	10	D. J. McDonnell & Bros., La Porte. Table Rock Mng. Co., N. M. Whims, Pres., Los Angeles, lessee with option	XVII, p. 477; XXV, pp. 198-199; Pre. Rep. 8, pp. 22, 39

Footnotes are at end of table.

TABLE OF MINES AND PROSPECTS, SIERRA COUNTY, WITH REFERENCES TO REPORTS OF STATE MINERALOGIST—Continued

Name	Kind of mine[1]	Section	Town-ship	Range[4]	Remarks[2] (Location or ownership)	References to Reports of State Mineralogist[3]
Table Rock	P					See Winkeye
Tailings	P	25, 36	21	9	John Rosenfeld & Son, 1024 Merchants Exchange Bldg., San Francisco	
Tefft	Q					XXV, p. 173
Telegraph Mng. Co.	Q	4	20	10	H. S. Tibbey, et al.	XI, pp. 410-412; XVI, p. 126; XXV, p. 187; XXXI, p. 3
Tennessee	P	1 (?)	21	10	R. M. Scott,[5] Downieville	
Thistle Shaft	P	25, 36	22	9	W. C. Wingate, Gibsonville, Mgr.	XI, pp. 331, 419; XII, pp. 265-266; XIII, p. 376; U.S.G.S. Prof. Paper 73, p. 106
Thousand and One	P	23, 24, 25, 26	20	12	Arthur E. Doss,[5] Martinez	XXV, p. 199. See text this report
Tightner	Q	27, 34	19	10	Original Sixteen to One Mng. Co.	XVI, pp. 127-129; XVII, p. 475; XVIII, pp. 143, 517-519; XIX, p. 73; XX, p. 83; Pre. Rep. 8, p. 39; U.S.G.S. Bull. 580, pp. 171-173; U.S.G.S. Prof. Paper 172, pp. 106-109
Tippecanoe	P	3	18	9	Geo. Parent, Pike	XIII, p. 384; XVI, p. 74
Tomboy Eureka	Q	29	19	10	O. R. Bixby, Forest	XVI, pp. 129-130; U.S.G.S. Prof. Paper 172, pp. 91-92
Topsey	Q				E. Prosser, Martinez	XX, p. 365
Tough & Hardy	P	6	18	9	W. B. Meek, Camptonville	XII, p. 273
True Fissure Gp.	Q	19, 30	21	12	True Fissure Cons. Quartz Mng. Co., Geo. Reynolds & Bishop, San Francisco	XI, pp. 405-406; XIII, p. 384; XVI, p. 130
True Grit & Eureka Cons. Gp.	P	26, 35	19	9	W. B. Meek & Mrs. Hathaway, Camptonville	XVI, p. 60
Twenty-One	Q	34 3	19 18	10 10	Original Sixteen to One Mng. Co.	XVI, pp. 130-131; U.S.G.S. Bull. 580, p. 174
Twenty-Two & Twenty-Three	Q	35	20	11	Lester I. Mather, 3515 5th Ave., Sacramento	
Uncle Sam	P	15, 16, 21, 22	19	10	John S. Binning, Alleghany; H. J. Gould, O. T. Owen, Forest. Lease and option to Wisconsin North Fork Gravel Mines, San Francisco	XIII, p. 380; XVI, pp. 60-61, 131-132; U.S.G.S. Prof. Paper 172, p. 25. See Wisconsin-North Fork
Union & Keystone	P	19, 20	22	10	T. C. Brown,[5] et al., 30 Cerritos Ave., San Francisco	See Miner's Home
Union Gp.	P	25	21	9	Jane Tomb	XVI, p. 61
Union Cons. Gp.	P					See Happy Hollow
Union Hill	P	18	20	9	Neocene Placer Mng. Co.,[5] C. P. Gardham, Secy., 944 Pine Grove Ave., Los Angeles	See text this report
Urelene	Q	5, 6	18	11		
Van Cliff	Q					See Slug Canyon Tunnel Co.
Van Slyke	P	11	20	11	J. W. Kerwin, Sierra City	
Virginia (Lincoln & Virginia)	P	5	21	10	Mrs. P. L. Carmichael, Table Rock; Becker Estate, C. J. Becker, Marysville; W. H. Hartley, Table Rock	XVI, p. 61. See text this report
Viola Gp.	P	19	19	11	Forest City Mng. Co., Downieville	
Wahoo Mng. Co.	P		20	9	Wahoo Mng. Co., Port Wine	U.S.G.S. Prof. Paper 73, p. 109
Wahoo & West Point	P				Frank Wehe, 74 New Montgomery St., San Francisco; and Arnot Estate	XX, p. 366

Washington	P	20, 21	22	10	C. M. Cox, Table Rock, via La Porte	
Washington & National	P	4 33	20 21	9 9	Washington Blue Gravel Mng. Co., 1107 Kohl Bldg., San Francisco. Blue Gravel Mines, Cons., lessee	See Lucky Gold Hill Co. in text this report
Waterfall	P	27, 28	20	12	Mrs. Marie E. Phelan, 2226 Capitol Ave., Sacramento	See text this report
Watts	P	14	19	9		XII, p. 274. See Steamboat
Wehe	P					See St. Charles Hill Gp.
Wehrle	P	Nr. Howland	Flat		Frank T. Wehrle, 795 Gray St., Oroville	See Loftus Blue Lead Mines Co.
Welker & Rossi Gp.	P	20	19	9	Indian Hill Mng. Co., Boston, Mass.	
Westall	P				E. J. Westall Estate, Sierra City	XIII, p. 378
West Point-Monte Cristo Gp.	P	16	20	10	T. E. Winrod, Downieville	XVI, p. 62; XX, p. 365
Wheeler, Yuba & Montpelier	Q	26	20	10	Emma Hughes, 512 N. Virginia St., Reno, Nevada	
White Bear	P, Cr	9, 16	20	10	White Bear Mng. Co., Richard Belcher, Secy., Marysville	XVI, pp. 30, 62-63; XXV, p. 211. See text this report
Wide Awake	P	12	20	10	H. H. Meyers and Estate of E. L. Case, Downieville	XI, p. 405; XII, p. 274; XIII, p. 384; XVI, p. 63
William Tell	Q	34	20	12	W. H. Williams, Agt., Sierra City	X, p. 653; XI, pp. 415-416; XVI, p. 132
Willoughby	Q	25	21	11	Gold Basis Mng. & Mg. Co., 1608 Webster St., Oakland; Robert Jump, Fruitvale; Ernest Farrel, Downieville	XVI, pp. 132-133; XXV, p. 173
Willow	P	14	20	12	Bradley-Haley Co., lessee	See Pride
Winkeye	P	32	22	10	Table Rock Mng. Co., c/o C. L. Falck, Woodleaf	XVI, pp. 63-64
Wisconsin-North Fork	P	9, 10, 15	19	10	Wisconsin-North Fork Gravel Mines, 103 Sanchez St., San Francisco	XVI, p. 64; XXV, p. 211
Wolf Creek	Q	12	18	10	Independence Mng. Co., Alleghany	
Wonder	Q				Wonder Gold Mines, Inc., 532 16th St., Oakland	XVIII, p. 519; U.S.G.S. Prof. Paper 172, p. 102
Wyoming	Q					U.S.G.S. Prof. Paper 172, p. 102
Yellow Jacket	Q				Under option to Alleghany El Dorado Gold Mng. Co.	See Osceola Gp.
Yellow Jacket	P	34	19	10	J. W. Evans, Graniteville; Wm. Cleary, Supt.	
Yellow Jacket & Bear Creek	Q	28, 33	19	11	Little Bear Creek Mng. Co., 260 California St., San Francisco	
Yellow Tiger Mng. Co.						See Gray Eagle
York	Q					See Finney
Young America	Q	8, 9	20	12	S. M. Green, Denver, Colo.	VI, pp. 57-58; VIII, pp. 577-578; X, pp. 643-647; XI, pp. 401, 407; XII, p. 275; XIII, p. 384; XVI, pp. 133-134; U.S.G.S. Rp. XVII, Pt. 1, p. 653
Young America 1, 2, 3, & Live Yankee	P	28, 33	19	10	Diamond Peak Dev. Co., c/o Wade Armstrong, Box 801, Nevada City	XII, p. 275; XVI, p. 64; U.S.G.S. Prof. Paper 172, pp. 92-94, 25
Yuba	P	13, 14 23, 24	21	12	Estate of Ed Westall, Sierra City	
Yuba Cons.	Q	10, 11	18	10	Sierra-Yuba Gold Quartz Mng. Co., J. L. Fields, trustee, 2141 Clinton Ave., Alameda	XVI, p. 134
Zuver	Cu	19	20	12		XVI, p. 31; Bull. 50, p. 189. See text this report

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[1] Asb, asbestos; Cr, chromium; Cu, copper; Fe, iron; P, gold placer; Q, gold quartz.

[2] Addresses are in California unless otherwise noted.

[3] Some references to publications of the United States Geological Survey (U.S.G.S.) are included. State Mineralogist's Report XVI in three separate volumes, one each for Nevada, Plumas, and Sierra County.

[4] All townships are north and all ranges are east of Mt. Diablo Base and Meridian.

[5] Names and addresses marked thus have been checked against the records of the Assessor of Sierra County for 1940. Names and addresses not so marked are those of the last person known to a representative of this division to have claimed ownership.

GEOLOGIC BRANCH

CURRENT NOTES

By Olaf P. Jenkins, Chief Geologist

RECENT PUBLICATION

A new state map, ''Economic Mineral Map No. 2, Oil and Gas,'' is now ready for distribution by the Division of Mines. It was prepared primarily to accompany Bulletin 118, ''Geologic Formations and Economic Development of the Oil and Gas Fields of California,'' though the map is also distributed separately. It shows all the oil and gas fields and areas in the state, the total productive acreage, the arbitrary boundaries of the so-called fields, the areas covered by maps available from the Oil and Gas Division, the wildcat wells drilled outside of the mapped areas, and many other valuable data. In the margin of the map is a chart showing the production history of the industry, a list and index to the fields, and a smaller map showing the major rock units and their relationship to the areas which are subject to exploration by oil geologists. A long tabulated list of wildcat wells, giving their location, their depth, their ownership, when they were drilled, and the geologic formations encountered at the bottom of each hole, is given in Part Three of Bulletin 118, and is to be used in conjunction with this map. The base of this oil and gas map is the same as that of the larger colored Geologic Map of California, only the oil and gas map has been reduced to one-half the scale, or 1 inch equals 16 miles. The geologic boundaries and symbols are left on the map so that it may serve as an index to the geology shown on the larger map, and to the text of Bulletin 118.

IN PRESS

Parts Three and Four of Bulletin 118 are now in press and when finally published will constitute a very large book. Part Three is on the ''Descriptions of Individual Oil and Gas Fields''; Part Four comprises ''Glossaries, Bibliography and Index.''

IN PREPARATION

State maps similar to ''Economic Mineral Map No. 1, Quicksilver,'' and ''No. 2, Oil and Gas,'' are now in preparation. A chromite map will be in press in a short time; this will be followed by a tungsten map. Maps on other strategic minerals are expected to be published as soon as time will permit for their completion.

Continued whole-hearted cooperation characterizes all this work of the Geologic Branch. Through the efforts of the California Academy of Sciences and Dr. Joseph S. Hollister, Research Associate of the Academy, still other mineral maps of the state are being compiled. In progress now are maps of magnesite, copper, iron ores, limestone, molybdenum, vanadium, and titanium.

The bibliography of the geology and mineral resources of California, which was so admirably carried on by the late Dr. Solon Shedd, of Stanford University, has been carried forward by his successor, Mr. LeVern Cutler, who has now completed bibliographies of this same broad subject matter, covering the years 1938 and 1939; these, however, have not yet been published.

SPECIAL ARTICLES

Detailed technical reports on special subjects, the result of research work or extended field investigations, will continue to be issued as separate bulletins by the Division, as has been the custom in the past.

Shorter and less elaborate technical papers and articles by members of the staff and others are published in each number of CALIFORNIA JOURNAL OF MINES AND GEOLOGY.

These special articles cover a wide range of subjects both of historical and current interest; descriptions of new processes, or metallurgical and industrial plants, new mineral occurrences, and interesting geological formations, as well as articles intended to supply practical and timely information on the problems of the prospector and miner, such as the text of new laws and official regulations and notices affecting the mineral industry.

CHROMIUM

By Chas. V. Averill
District Mining Engineer, Sacramento

OUTLINE OF REPORT

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ECONOMIC STATUS OF CHROMIUM

Chromium as an alloying element for the improvement of steel in strength, toughness, and resistance to corrosion is of great importance in modern industry, and that importance is increasing. It is on the list of strategic metals of the United States Government, that is, chromium is essential to National defense, and the normal supply comes from sources outside the continental limits of the United States. In the years 1925 to 1939, consumption averaged about 300,000 long tons of ore (chromite) per year, although in 1937, more than 500,000 tons was used. Owing to defense activities, consumption late in 1941 was at the rate of 800,000 long tons per year.

World production amounts normally to about 1,000,000 tons per year, and the principal producers are Southern Rhodesia, Turkey, Union of South Africa, and U. S. S. R. (Russia). Cuba and India are fairly large producers, and the Philippine Islands have entered the ranks of large producers during the past few years. With the exception of Russia, the producing countries are small consumers, and most of the chromite produced enters international trade.[1] Very large reserves of chrome ore are believed to exist in Africa.

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[1] See also: Ridgway, R. H., Shifts in chromite supply: U. S. Bureau of Mines I. C. 6886, pp. 1-11, 1936.

In the United States production has been very low in recent normal years. A little chrome ore has been produced in California in recent years, and substantial production was made here during the war of 1914-18. Since 1939 much effort has been devoted to developing domestic reserves, and substantial reserves are known in California, Oregon, and Montana. Late in 1941, a mill was under construction in Montana to produce concentrate from a deposit containing more than 1,000,000 tons[2] of ore running 23 to 26 percent Cr_2O_3. In California one mill was in operation in El Dorado County, and a second was to be built in Glenn County. Stock-piles of high-grade ore were being accumulated at several places, notably in Placer County and Shasta County.

Chrome ore has three distinct types of uses in the following order of importance: (1) as a source of chromium for alloying with steel, (2) as a refractory, and (3) for the manufacture of chemicals.

(1) Chromium-steels may be high, medium, or low in carbon, and high, medium, or low in chromium, depending on what properties are desired. Other elements added to some chromium steels are manganese, silicon, nickel, copper, molybdenum, vanadium, tungsten, nitrogen, aluminum, zirconium, titanium, and columbium. A range in phosphorous content has also been used. This allows an infinite number of compositions, of which probably several hundred are in commercial use. Practically all of these steels receive special heat-treatment, which can be varied to give desired properties. Many of the chromium-steels and chromium-irons are described in a recent two-volume work by Kinzel[3] and others. Some of these steels are several times as strong as ordinary structural steel, and a machine-part of a certain strength can be made smaller and lighter. They are used in the modern airplane engine and automobile, which would be almost impossible to make without chromium-steels.

The gears, steering knuckles, axle shafts, connecting rods, and probably the cylinder-block, of your automobile contain chromium. Truck-parts must be stronger and are likely to contain still more chromium.

Chromium-steels are used in military tanks, guns, armor plate, and projectiles. Many modern chemical industries are dependent on chromium-steels that resist corrosion, similar to the stainless cutlery steels. The handling of nitric acid and high-pressure, high-temperature oil-refining are examples.

Many of the chromium-steels are quenched from a high temperature to harden them, and are then tempered by heating for a short time to a lower temperature. However, not all of the chromium-steels behave in this way. A steel containing 18 per cent chromium, 8 per cent nickel, and low carbon (about 0.07 per cent) is soft after rapid cooling from a high temperature. It can be cold-drawn into wire and cold-rolled into sheets. This treatment increases the hardness and the tensile strength. This steel is resistant to oxidation and chemical corrosion.

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[2] U. S. Bureau of Mines R. I. 3574, p. 4, 1941.

[3] Kinzel, A. B. and Crafts, Walter, The Alloys of Iron and Chromium, vol. 1, Low-Chromium Alloys, 1937.

Kinzel, A. B. and Franks, Russell, The Alloys of Iron and Chromium, vol. 2, High-Chromium Alloys, 1940.

(2) Chromite as a refractory is much used in the form of bricks. The neutral chromite is used as an insulating layer in the lining of open-hearth steel furnaces between the basic (magnesite) hearth and the acid (silica) roof. This layer is very resistant to corrosion by the slag. A small amount of the raw ore is used in the same way, and a small amount as refractory cement. Grades of chromite containing less than 45 per cent Cr_2O_3 are often satisfactory as refractories. Manufacturers of chrome brick prefer lump-ore so that grinding can be done to their own specifications.

(3) Chromium chemicals are used in the dyeing, tanning, and pigment industries. Pigments of green, yellow, orange, and red shades are made. In chromium plating, the metal must be deposited from a bath of chromic acid. A metallic chromium anode is not used, and the deposited metal is derived from the bath. Hence this is usually regarded as a chemical use.

Chrome ore for use in chemicals is largely converted into chromates by roasting with lime and soda. High-grade ore is desired so that the bulk of the material handled is small. Low silica (5 to 8 percent) is desired to limit the amount of sodium silicate formed. The lime is added to help the handling of the mixture in the roaster. Any calcium chromate formed is later converted into sodium chromate. The sodium chromate is dissolved in water; the solution is filtered, concentrated by evaporation, and sodium chromate is crystallized.[4]

A few notes on the principal chrome pigments follow:

Chrome yellows are compounds of lead and chromic acid, which range in color from deep orange to light yellow.

Zinc chromate and barium chromate are of light yellow color.

Chrome greens are mixtures of Prussian blue and chrome yellow in various proportions according to shade.

Chrome oxide green is made of chromic oxide and is of a dull color called also viridian.

Zinc green is a mixture of zinc chromate and Prussian blue.

Chrome red (American vermillion) is a basic chromate of lead.

MARKETING

California miners who are accustomed to tons of 2000 pounds should note carefully that chrome ore is marketed in long tons of 2240 pounds. Failure to realize this has caused some recent financial difficulty among small-scale miners of chrome ore.

Marketing of chrome ore for metallurgical use, the most important use, is better understood if subsequent processes are considered. The bulk of the chromium added to steel is added as ferrochromium, which is made in the electric furnace, and for the proper working of the furnace lump-ore is desired. For some grades of steel, a ferrochromium low in carbon must be used to keep the carbon low in the finished steel. Hence a large amount of chromium is desired in the ferrochromium, say 70 percent chromium. This in turn means that the original ore must be high in chromium; otherwise too much iron goes into the ferrochromium from the ore. Specifications usually call for 48 percent Cr_2O_3 and a ratio of metallic chromium to metallic iron of 3 to 1.

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[4] See also U. S. Bureau of Mines I. C. 6566, Chromium, and R. I. 2999, Roasting of chromite ores to produce chromates.

To obtain the percentage of metallic chromium from the percentage of Cr_2O_3 multiply by 0.684. Iron is often reported as metallic iron, but if it is reported as FeO multiply by 0.777 to get the percentage of metallic iron.

The following are from recent specifications of the U. S. Treasury Department for stock-piling:

''Element	Percentage
Chromium Oxide (Cr_2O_3) (minimum)	48.0
Iron (metallic) (maximum)	$\frac{1}{3}$ of the actual percentage of chromium (metallic)
Sulphur (maximum)	0.50
Phosphorous (maximum)	0.20

''Chromium ore shall be furnished in lumps. All lumps shall pass a 6-inch screen. Not more than 10 percent shall pass a $\frac{1}{2}$-inch mesh sieve.'' Lower specifications of Metals Reserve Company are given herein under ''price.''

Much of the chromite found in California has a lower ratio of chromium to iron than 3 to 1, and hence very little, if any, California chromite has found its way into U. S. Government stock-piles.

One manufacturer of large amounts of stainless steel uses a patented process in which chrome ore is fed directly to the electric furnace. Ferrochrome is not essential to this process, but some is used when it can be bought at a low price. Chromite that has been ground to fine size for concentration can be used in this process; also chromite with a lower chromium-iron ratio than 3 to 1. Concentrates running 45 percent Cr_2O_3 and with a chromium-iron ratio of slightly less than 2 to 1 have been used.

PRODUCTION HISTORY IN CALIFORNIA

Although chromite was discovered in the Maryland-Pennsylvania district in 1810, mining did not start until 1827. In that year Isaac Tyson, Jr., started to produce chrome ore, and later (1845) to manufacture chromium compounds, yellow and green pigments for decorating carriages and furniture. Tyson and Company started to ship chrome ore to Baltimore in 1869 from properties in Del Norte County on French Hill and Low Divide. Shipments of 1500 to 2000 tons annually continued for 20 years. In 1881 deposits were opened in San Luis Obispo County which yielded 6000 tons of ore during the next two years. Competition from Turkish ore reduced the price of California ore from \$12 to \$9 per ton between 1881 and 1890, and production of California ore ceased in 1896. Chromite was subject to a duty of 15% from 1883 until 1894; it was then put on the free list. Production was very low until the war of 1914-18. During the five war-years California production amounted to a total of 161,177 long tons. Many persons had invested more money than they could afford in producing California chrome ore in those years, and when the price dropped suddenly at the end of that war, they were left with stocks of high-cost chrome ore on hand; also with equipment that could no longer be used. The U. S. Government later paid part of these

CHROMITE

Year	*World production long tons*	*California shipments long tons*	*U. S. consumption long tons*	*Average value per long ton of domestic sales*
1890	36,000	3,599	7,952	$15.00
1891	32,000	1,372	5,831	15.00
1892	21,000	1,500	6,430	16.60
1893	44,000	3,319	7,804	15.00
1894	56,000	3,680	7,150	14.40
1895	43,000	1,740	6,970	9.60
1896	56,000	786	9,455	8.40
1897	46,000	------	11,570	------
1898	47,000	------	16,304	------
1899	48,000	------	15,793	------
1900	50,000	140	17,682	10.00
1901	62,000	130	20,480	15.73
1902	62,000	315	39,885	14.50
1903	61,000	150	23,082	15.00
1904	101,000	123	24,350	15.00
1905	106,000	36	54,456	17.05
1906	126,000	283	43,548	16.82
1907	138,000	270	42,279	19.45
1908	115,000	312	28,235	20.14
1909	124,000	389	40,222	13.88
1910	119,000	669	38,784	13.31
1911	126,000	835	37,795	13.58
1912	165,000	1,134	54,134	13.70
1913	174,000	1,054	65,435	11.19
1914	186,000	1,354	75,277	14.75
1915	158,000	3,326	76,736	11.20
1916	263,000	43,699	162,980	15.44
1917	246,000	46,767	115,788	24.00
1918	325,000	66,031	182,572	47.99
1919	143,000	(1)3,852	66,483	25.46
1920	235,000	1,580	152,777	17.93
1921	129,000	310	81,118	10.28
1922	144,000	338	90,081	20.53
1923	199,000	75	128,763	16.82
1924	287,000	312	118,343	3.94
1925	303,000	170	149,847	19.49
1926	358,000	351	215,464	14.74
1927	403,000	201	222,360	25.19
1928	450,000	651	216,592	22.43
1929	602,000	292	317,630	14.78
1930	550,000	75	326,697	23.81
1931	378,000	394	212,769	13.09
1932	294,000	158	89,143	13.94
1933	255,000	919	116,517	13.96
1934	607,000	262	192,297	14.10
1935	781,000	436	259,063	13.76
1936	1,051,000	197	324,256	11.07
1937	1,260,000	1,712	556,237	6.41
1938	1,115,000	877	352,897	13.21
1939	1,149,000	3,514	321,125	12.98
1940	--------	2,321	660,351	10.81

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(1) Recalculated to 45 percent Cr_2O_3, beginning in 1919 for California shipments. The above table for California's shipments was compiled from the reports of the State Division of Mines. In the case of world production, this item was transposed from metric tons to long tons for years 1938 and 1939. The California shipments were changed from short tons to long tons and from 1919 on were recalculated to 45 per cent Cr_2O_3. Values are average prices received per long ton for domestic shipments.

losses, but in most cases did not pay the entire amount of the loss. Production then averaged less than 1000 tons per year until the present war started, when rising prices again stimulated production. In 1940 the California production was 2321 tons and for 1941 it will be considerably higher.

MILLING

If the mineral-grains of chromite contain a low percentage of Cr_2O_3, nothing can be done by ordinary mechanical methods of milling to raise the grade. Some ores contain grains of a mineral very low in Cr_2O_3 called picotite, which causes trouble in milling. However, if the pure chromite present in the ore contains a high percentage of Cr_2O_3, and gangue minerals such as olivine, serpentine, magnesite, quartz, or jasper are also present, a concentrate of satisfactory grade can often be made by milling. Several processes are available: gravity concentration, flotation, and magnetic separation.

A number of mills were erected during the war of 1914-18 to crush chrome ore with stamps and to make a concentrate on vibrating tables. Results were rather poor for two reasons: (1) stamps make too much slime, and (2) not enough attention was given to classification, so that tables were fed with material of too great a range of size in grain, and good adjustment was not possible. Ball mills also make too much slime.

Flotation has given excellent results in the laboratory on some ores. However, the tendency at the present time is to mine oxidized ore near the surface. This ore is friable and can be crushed and ground cheaply. It can also be mined cheaply by power shovel. Such ore makes a difficult problem in flotation because variations in the degree of oxidation require constant adjustment of flotation. The method is better adapted to unoxidized ores.

Magnetic separation has given promising results on some ores. The feed to magnetic machines must be sized and results are good on 40-mesh material. However, much material of finer sizes is unavoidably made during grinding, and results are not so good on this. The magnetic permeability of chromite low in iron is low, and an olivine gangue has a slight permeability. This effect together with molecular attraction and dusting makes separation difficult in the fine sizes.

The following is suggested as good practice for gravity concentration: three-stage crushing with crusher, rolls and rod-mill; hydraulic classifier to deliver say six different sizes; concentration in jigs and on tables, a separate table to be provided for each size delivered by the classifier. It may be desirable to regrind table-middlings either in the main circuit or in a separate circuit. The slime-loss will still be considerable in such a mill, and it is to be hoped that flotation can be perfected to overcome this loss. Each ore should be tested before a mill is designed. See U. S. Bureau of Mines Reports of Investigations 3328 and 3049.[5]

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[5] Doerner, H. A., Concentration of chromite: U. S. Bureau of Mines R. I. 3049, pp. 1-8, 1930.

METALLURGY

In the ordinary process of making chromium steels, ferrochrome is utilized in the electric furnace; and for low carbon steels, low carbon ferrochrome must be used. The ferrochrome has previously been made in an electric furnace, and in order to keep the ratio of chromium to carbon high the ore must be high in grade. This is the reason that 48% Cr_2O_3 is usually specified and a chromium to iron ratio of 3 to 1. When such ore is used the ratio of the chromium to both the iron and the carbon is high. The low carbon ferrochrome required in some of the steels is made from either high-carbon ferrochrome or chrome ore by a rather expensive process. Formerly metallic aluminum was used as a reducing agent to produce low-carbon ferrochrome, but more recently silicon or an alloy high in silicon has been used. To indicate the high cost of these processes the following quotations for ferrochrome, which were in effect late in 1941 are given: the price per lb. of chromium in an alloy containing 4% to 6% carbon and 66% to 70% chromium was 13¢; for 2% carbon and 67% to 72% chromium, the price per lb. of chromium was 19½¢; for a maximum of 0.10% carbon the price per lb. of chromium was 22½¢.

One corporation uses a patented process to eliminate the ferrochrome from the process either wholly or at least in part. As this process seems better adapted to the average grade of chrome ore found in California than the more commonly used process utilizing ferrochrome, a few details are abstracted from the patents. Perhaps the time will come when the demand for chromium steels in the west is such that the owner of these patents will construct an electric furnace in California or perhaps the proper arrangements for the use of the patents will be made by others.

Patent No. 1,925,182[6] states that in the production of rustless iron and steels, large quantities of rustless iron-scrap become available about the steel plant, such as imperfect ingots, ingot butts, crop ends, and the like. Likewise, considerable quantities of rustless scrap become available in the various customer plants where rustless iron sheet, strip, bars, and the like are fabricated. No commercial outlet for these large quantities of rustless iron-scrap has heretofore been available.

In the practice of this invention an electric furnace of the well-known Heroult type is preferred, lined to a height of somewhat above the slag line with chromite brick carrying a superimposed rammed-in and formed layer composed of approximately three parts, by weight, of crushed chrome ore and one part of ground magnesite. Water-glass serves as a good binder for this rammed-in part of the bottom lining. Either carbon or graphite electrodes are employed with the voltage available in several steps over the range from 100 to 180 volts.

The first patent mentioned above contemplated the use of high-carbon ferrochrome as the source of the chromium, but a later patent, No. 1,954,400, contemplates the use of chrome ore. This invention has particularly to do with the remelting or reclaiming of rustless iron-scrap in the manufacture of rustless iron. In accordance with this process, as briefly outlined, an electric furnace, such as the usual carbon-electrode Heroult steel-making furnace, is charged with rustless iron-scrap, a material high in iron oxide such as roll scale, and chrome ore.

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[6] Feild, A. L., Baltimore, Md., assignor to Alloy Research Corporation, Baltimore, Md., patent issued Sept. 5, 1933. (Copies of patents are obtainable at U. S. Patent Office, Washington, D. C., at 10¢ each.)

The charge is melted and the bath brought to a relatively high temperature, higher than that usually employed in steel melting-down operations. The roll scale and chrome ore form a supernatant slag on the molten iron. The iron oxide in the roll scale behaves as an energetic oxidizing agent, and the iron oxide contained in the chrome ore also possesses the same characteristic. Its presence in the slag on the molten metal serves as a carbon oxidizing barrier to prevent the carbon from the electrodes from getting into the metal. The iron oxide also tends to oxidize any carbon which may be present in the scrap charge. At the temperature used, chromium has a great affinity for both carbon and oxygen. Hence oxidized chromium goes into the slag during this step.

In the second stage of the operation, a mixture of burnt lime, preferably preheated to eliminate moisture, and a silicon reducing agent, preferably 75% ferrosilicon, is charged onto the slag, whereupon the iron and chromium oxides in the slag are reduced to metallic iron and chromium and enter the metal layer. If desired, some chrome ore may be charged with the lime and silicon reducing agent, particularly when a ferrosilicon having a high percentage of silicon is employed. After complete (90% or better) reduction of chromium accompanied by substantially complete reduction of iron oxide out of the slag into the metal bath has been accomplished, the slag is preferably drawn off, and a conventional finishing slag of lime, pulverized ferrosilicon, and fluorspar is formed on the bath. Final additions to bring the metal to the proper specifications, such as the additions of lump ferrosilicon, or low-carbon ferromanganese, or other alloying additions, are then made and the heat is tapped. The greater part, if not all, of the additional chromium for enrichment of the metal is secured from chrome ore, which is a cheap source of chromium.

The following is a typical heat made in accordance with this process. The furnace is given an initial charge consisting of 12,600 pounds of rustless iron-scrap analyzing about 17% chromium and about 0.10% carbon; 3250 pounds of plain low-carbon steel scrap; 2850 pounds of chromite ore containing about 48% chromium oxide (Cr_2O_3); and 1000 pounds of roll scale which is substantially 100% magnetic iron oxide, and from which about 70% metallic iron is recovered. The power is applied and the charge is rapidly melted and brought to a relatively high temperature, preferably considerably above the temperature ordinarily employed for the usual steel melting-down operation in an electric furnace, approximately 3050° to 3200° F. After determining by analysis of metal samples taken from the bath that the carbon content of the bath is at or below the desired maximum percentage, usually 0.10%, the second or reducing step is carried out by adding to the bath about 4500 pounds of hot dry burnt lime, 1400 pounds of crushed 75% ferrosilicon, and 125 pounds of manganese ore. When the addition of lime and ferrosilicon has fused and become thoroughly incorporated in the slag, and when the reducible oxide content of the slag has been lowered to a relatively small percentage, for example 2% or lower of iron and chromium oxide, this slag is drawn off substantially clean. A conventional basic finishing slag is then made up and added onto the bath. Such final additions of lump low-carbon ferrosilicon and low-carbon ferromanganese are added as may be needed to adjust the analysis of the bath to the required specifications. The heat is then tapped. In the case of the illustrative example, a product is obtained weighing 17,300 pounds and analyzing about 0.08% carbon, 17% chromium, 0.35% silicon, and 0.40% manganese, with sulphur and phosphorous in normally low percentages.

Patent No. 1,925,916 relates to the predrying and preheating of all of the materials used in the process including the lining of the furnace. This is necessary because at the high temperatures used the oxygen is removed from any water vapor present, and the hydrogen is left behind in the metal, where it is likely to cause blowholes.

Patent No. 2,056,162 [7] relates to the use of a minimum quantity of high-carbon (1% to 10%) ferrochrome to achieve a tapped metal of the desired chromium content comparatively free of undesirable oxide inclusions. This patent also contemplates the use of a maximum quantity of chrome ore to provide a cheap source of chromium. The furnace used in the example given in this patent is a six-ton Heroult furnace rated three-phase 25 cycles 2500 kv-a and 100 to 180 volts.

Another process [8] that seems to have considerable promise is one worked out in the laboratories of the United States Bureau of Mines. This process contemplates the production of chromium chloride from low-grade chrome ore and the reduction of the chloride to pure chromium metal by means of hydrogen gas. The process has been operated successfully on a laboratory scale to produce chromium metal of extremely high purity. The temperature used was only 800° C. in contrast to temperatures used in electric furnaces of about 2000° C. So far as the present writer knows this process has not yet gone beyond the laboratory stage.

PRICE

The normal average price of chrome ore f.o.b. Atlantic ports for the years 1919 to 1939 fluctuated a few dollars above and below $20.00 per long ton. The 1921 average price was only $10.28, but that was abnormally low. Different grades bring different prices. The range for 1930 was from $19.50 to $24.

The California production for 1939 was $52,673 at the rate of $15.00 per long ton f.o.b. nearest rail-station to the mine.

Metallurgical ore of 48% Cr_2O_3 (other specifications above) was quoted at $45.00 to $47.00 per long ton at Atlantic ports in the fall of 1941. Refractory ore of 43% to 45% Cr_2O_3 was quoted at $30.00 to $32.00.

The price in California should be the eastern price less the freight. A brokerage charge may be made on small lots. All-rail freight on a long ton from Auburn, California to Baltimore, Maryland, in the fall of 1941 was $17.25. In normal times several dollars per ton may be saved on freight by shipping through the Panama Canal.

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[7] Arness, William B., Baltimore, Md., assignor, by mesne assignments, to Rustless Iron and Steel Corporation, Baltimore, Md.

[8] Dean, R. S., et al., Progress report, Metallurgical Division; U. S. Bureau of Mines R. I. 3419, pp. 7-8, 1938.

The average price paid for chrome ore in California in 1918 was \$49.35 per ton, but a peak of \$1.50 per unit of Cr_2O_3 was reached. To get the price per ton from the price per unit, multiply by the percentage of Cr_2O_3 in the ore. Thus the peak price per ton in 1918 for 48% ore was 48 x 1.50 = \$72.00.

With the return of normal shipping conditions from such places as Turkey, Africa, and the Philippine Islands, a sharp drop in the price of chrome ore is to be expected.

Persons interested in selling chrome ore to the U. S. Government should communicate with Metals Reserve Company, Washington, D. C. The following schedule of that company is quoted in full:

METALS RESERVE COMPANY

Washington, D. C.

February 20, 1942.

INFORMATION CONCERNING PURCHASE OF DOMESTIC CHROME ORES

Superseding Schedule dated December 19, 1941

For the benefit and guidance of producers desiring to make offers of low-grade chrome ores, Metals Reserve Company herein provides information describing in detail the specifications, price schedules, conditions of shipment and delivery, sampling and analysis which will be included in contracts for the purchase of chrome ores.

The terms under which Metals Reserve Company will purchase domestic chrome ores are subject to change without notice, and the terms and provisions of each contract will be based on conditions and circumstances existing at the time of acceptance. The policies herein outlined do not apply to ores originating outside the limits of continental United States.

The changes contained herein are applicable at the Seller's option to all contracts which have been granted under the schedules dated November 14, and December 19, 1941.

1. *Quantity:* One thousand (1,000) to ten thousand (10,000) long tons per contract. Contracts in excess of ten thousand tons may be obtained as a result of individual negotiations, provided reliable and complete engineering data submitted by the applicant warrants a contract for a larger quantity.

2. *Term of contract:* Deliveries must be completed within eighteen (18) months of date of contract. If delivery of twenty percent (20%) of the tonnage contracted for has not been made within six months of date of contract, Buyer may cancel contract forthwith.

3. *Quality:* Purchases of domestic chrome ores will be of three grades, with the following specifications:

	"High Grade"	*"Low Grade A"*	*"Low Grade B"*
Chrome (Cr_2O_3)—Minimum	45.0%	40.0%	40.0%
Silica—Maximum	11.0%	13.0%	No maximum
Phosphorus—Maximum	0.20%	0.50%	No maximum
Sulphur—Maximum	0.50%	1.00%	No maximum
Chrome (Cr)—Iron (Fe) Ratio—Minimum	2.5 to 1	2.0 to 1	No minimum

a) *Concentrates of chrome ore,* if briquetted, are acceptable under the schedule of prices and the terms and conditions herein.

b) *Unconsolidated chrome concentrates,* if of "High Grade" or "Low Grade A" specification, will be accepted under this schedule at a discount of \$3.00 per long ton.

Size of ore: None in excess of 12 inches. In "High Grade" and "Low Grade A" not more than 40% to pass a 1 inch screen. Requirements as to amount of fines are waived on "Low Grade B."

Buyer may reject any shipment which does not conform to the applicable requirements and specifications as set forth above.

4. *Price:* Effective February 24, 1942, contracts will be considered on the following schedule for domestic ores within continental United States (excluding Alaska); all prices per long ton (2240) pounds of dry weight, f.o.b. cars at stockpile designated by Buyer.

"High Grade"—Base price, $40.50 per long dry ton for ore containing 45.0% Cr_2O_3, and with a ratio of chrome (Cr) to iron (Fe) of 2.5 to 1; with an increase of ninety cents (90¢) per ton for each unit Cr_2O_3 in excess of 45.0% Cr_2O_3; with an increase of one dollar fifty cents ($1.50) per ton for each tenth increase in chrome-iron ratio to a maximum of 3.0 to 1. The chrome content of any ore is 68.4% of its chromic oxide (Cr_2O_3) content.

"Low Grade A"—Base price, $28.00 per long dry ton for ore containing 40.0% Cr_2O_3, and with a ratio of chrome (Cr) to iron (Fe) of 2.0 to 1; with an increase of ninety cents (90¢) per ton for each unit Cr_2O_3 in excess of 40.0% Cr_2O_3; with an increase of one dollar fifty cents ($1.50) per ton for each tenth increase in chrome-iron ratio to a maximum of 3.0 to 1.

"Low Grade B"—Base price, $24.00 per long dry ton for ore containing 40.0% Cr_2O_3, with an increase of sixty cents (60¢) per ton for each unit Cr_2O_3 in excess of 40.0% Cr_2O_3.

Fractions prorated in all cases.

Under the contract, each lot will be priced under the grade within which the specifications fall. Thus a lot carrying 45.0% Cr_2O_3 and 0.50% phosphorus would be priced as "Low Grade A."

In addition to the above prices, an allowance will be made for each long ton shipped equal to the freight tariff per long ton from Seller's nearest convenient rail station to Buyer's stockpile.

The cost of sampling and analysis by the Buyer, weighing, and unloading onto stockpile will be for the account of Buyer.

5. *Shipment and Delivery:* Seller will give such advice regarding shipment and arrival as Buyer may require, at least ten days prior to shipment of the ore from point of loading onto railroad cars; otherwise, any demurrage at the stockpile will be for Seller's account.

Shipment will be made in flat bottom gondolas, if available, in lots of not less than one carload, to the stockpile designated by Buyer. Seller will prepay the freight to such stockpile, where the ore will be weighed in cars, light and loaded, on track scales, and sampled for moisture. The lot will be sampled as unloaded and upon receipt of analysis, Buyer will advise Seller as to whether the ore is acceptable and under what classification.

If the lot is ascertained to be unacceptable under the above specifications, Seller will not be entitled to any allowance for prepaid freight and will be held responsible for the removal of this shipment of ore from the stockpile location. Upon failure so to remove the ore within fifteen days of the due notice, Buyer may, at its absolute discretion, remove such ore and the cost of such removal shall be for Seller's account; or Buyer may, at its option, otherwise dispose of such ore without any liability therefor. In the event that Seller fails to repay Buyer, within fifteen days after notice, for the cost of removal, Buyer may cancel the contract forthwith.

6. *Payment:* As soon as moisture and analysis determinations are received, Buyer will promptly pay Seller in accordance with the weight certificate and the above schedule.

7. *Weights:* The weight paid for will be net railroad track scale weights (weight of loaded car less weight of empty car), less moisture as determined by standard practice.

8. *Sampling and Analysis:* Each lot will be sampled at the time of unloading onto stockpile by a sampler designated by Buyer, three samples being taken, one each for Seller, Buyer, and Umpire, and analysis made for chrome and other guaranteed elements. Usual provisions will be made for splitting limits and settlement by average of Seller's and Buyer's analyses, or by trade practice if samples are sent to Umpire. Moisture samples will be taken in accordance with standard practice. Seller may have representative at sampling at his own expense.

9. *Applications for Contracts:* See next page for form of "Application for Contract" and if applying for a contract, either fill in, sign, and mail the form, or submit similar information in a separate letter, using the forms as a guide. All the

information called for on the application form must be supplied before consideration can be given to granting a contract.

APPLICATION FOR CONTRACT

METALS RESERVE COMPANY
811 Vermont Avenue, N. W.
Washington, D. C.

____________________, ____________
(Place) (Date)

Gentlemen:

Hereunder is my application for a contract to sell Metals Reserve Company ____________________long tons of domestic chrome ore.
(State tonnage)

1. Name of applicant: ____________________
(State whether individual, partnership, association or corporation.) (If other than as an individual, give full and correct name of the partnership, association or corporation.)

2. Address of the applicant, partnership, association or corporation:
____

3. Business references:
(1)____________________, ____________________
(Name) (Address)
(2)____________________, ____________________
(Name) (Address)

4. Exact name and location of mine, deposit or claims from which the ore is to be produced.
Name____________________
Location____________________

5. Rate of expected delivery on contract applied for: ____________cars per month.
(State number)

6. Name of railroad station or siding from which shipments will be made:
____

7. Analysis of ore offered for contract: ________% Chrome; ________% Silica; ________% Phosphorus; ________% Sulphur; ________to 1 Chrome-Iron Ratio.

8. Experience of applicant in mining this or other types of ore:
____
____
____
____
____
____

9. Brief description of mine, deposit or claims; extent of exposures, ore developed, ore stockpiled at mine (if any), underground or surface development equipment (if any), etc.:
____
____
____
____
____
____
____

____
(Signed)

____
(Title)

(Use additional sheets if necessary, to make information complete under any of the headings.)

6—11057

PURCHASE OF TRUCKLOAD LOTS OF CHROME ORE: OREGON AND NORTHERN CALIFORNIA, WITHOUT FORMAL CONTRACTS

The Metals Reserve Company, Washington, D. C., the government agency buying strategic minerals under date of March 5, 1942, has released the following statement:

In order to stimulate production of chrome ore from small deposits located in Oregon and Northern California and to provide a ready market for such ores, Metals Reserve Company (herein sometimes called "Buyer") has arranged to purchase in truckload lots from the producer (herein called "Seller") chrome ore mined either in Oregon or Northern California. The terms and provisions of this Circular will be effective until April 1, 1943.

1. PURCHASE DEPOTS. Such chrome ores may be delivered and, subject to the provisions of this Circular, will be accepted in lots of one or more than one truckload at Purchase Depots established by Buyer. Purchase Depots, where Purchasing Agents will be available, will be located at Coquille, Grants Pass, Seneca, Oregon; Yreka, California, or at other Purchase Depots established by Buyer. Ore or concentrates delivered to Purchase Depots under the terms and provisions of this Circular will not be accepted as delivery under nor will same be applied against contracts entered into by Metals Reserve Company under Schedules of November 14, 1941, December 19, 1941, or February 20, 1942.

2. SPECIFICATIONS. Purchase of such ores will be limited to three grades of the following specifications:

	"High Grade"	*"Low Grade A"*	*"Low Grade B"*
Chrome (Cr_2O_3)—Minimum	45.0%	40.0%	40.0%
Silica—Maximum	11.0%	13.0%	No maximum
Phosphorus—Maximum	0.20%	0.50%	No maximum
Sulphur—Maximum	0.50%	1.00%	No maximum
Chrome (Cr)—Iron (Fe) Ratio—Minimum	2.5 to 1	2.0 to 1	No minimum

3. CHROME CONCENTRATES.

(a) If briquetted, are acceptable under the schedule of prices and terms and conditions herein.

(b) Other chrome concentrates, if of "High Grade" or "Low Grade A" specification, will be accepted under this schedule at a discount of $3.00 per long ton.

4. SIZE OF ORE. None in excess of 12 inches. In "High Grade" and "Low Grade A" not more than 40 per cent to pass a 1-inch screen. Requirements as to amount of fines are waived on "Low Grade B."

5. PRICE. Effective April 1, 1942, purchases will be made in accordance with the following schedule (all prices quoted being per long ton—2,240 pounds avoirdupois—dry weight at Purchase Depot): "High Grade"—Base price, $40.50 per long dry ton for ore containing 45.0% Cr_2O_3, and with a ratio of chrome (Cr) to iron (Fe) of 2.5 to 1; with an increase of ninety cents (90¢) per ton for each 1.00% Cr_2O_3 in excess of 45.0% Cr_2O_3; with an increase of one dollar fifty cents ($1.50) per ton for each tenth increase in chrome-iron ratio to a maximum of 3.0 to 1. (The chrome content of any ore is 68.4% of its chromic oxide (Cr_2O_3 content.)

"Low Grade A"—Base price, $28.00 per long dry ton for ore containing 40.0% Cr_2O_3, with a ratio of chrome (Cr) to iron (Fe) of 2.0 to 1; with an increase of ninety cents (90¢) per ton for each 1.00% Cr_2O_3 in excess of 40.0% Cr_2O_3; with an increase of one dollar fifty cents ($1.50) per ton for each tenth increase in chrome-iron ratio to a maximum of 3.0 to 1.

"Low Grade B"—Base price, $24.00 per long dry ton for ore containing 40.0% Cr_2O_3, with an increase of sixty cents (60¢) per ton for each 1.00% Cr_2O_3 in excess of 40.0% Cr_2O_3.

Fractions prorated in all cases.

The price of each lot will be determined by the specification under which it falls.

Seller must, at his own expense, deliver all ore or concentrates to and unload same at Purchase Depot.

Buyer will pay the cost of weighing, sampling, and analyzing.

6. WEIGHING. The weight of each truckload will be determined by a Metals Reserve Company weighmaster on scales which will be provided by Metals Reserve Company at or in the vicinity of the Purchase Depot. A weight ticket will be furnished Seller for each lot.

7. SAMPLING AND ANALYSIS. Each lot of chrome ore will be sampled at the time of unloading by a Metals Reserve Company sampler. Analysis will be made by a Metals Reserve Company analyst.

8. PAYMENT. As soon as analysis, including moisture determination, is obtained, settlement sheet, together with check in payment, will be mailed to Seller from Buyer's Portland, Oregon, office. Weighing, sampling, analysis and classification by Metals Reserve Company shall be final and conclusive.

9. REJECTION. Buyer will reject any ore or concentrates which do not conform to the applicable requirements and specifications set forth above. Any and all ore rejected by Buyer must be removed by Seller within 15 days after mailing of notice of rejection. Any and all ore not removed by Seller as above provided may, at the option of Buyer, be removed or otherwise disposed of by Buyer without any liability therefor.

Names and addresses of others who are definitely known to have purchased California chrome ore in 1941 follow:

Bradley and Eckstrom, 320 Market Street, San Francisco, California.

Columbia Steel Company, Russ Building, San Francisco, California.

Ronald N. Knudsen, Freeman Hotel, Auburn, California.

Ohio-Ferro-Alloys Company, Tacoma, Washington. This company has two electric furnaces making ferrochrome at Tacoma.

Rustless Mining Corporation, Box 516, Grants Pass, Oregon.

U. S. Vanadium Corporation, 114 Sansome Street, San Francisco, California.

Don Woodrum, Golden Eagle Hotel, Redding, California.

GEOLOGY

The following brief description of the geology of chromite deposits is intended to emphasize as much as possible the point of view of persons who are interested in geology as a tool to help them find and develop additional domestic reserves of chrome ore. Two points are of great assistance in this regard. First, all chromite deposits in the world are associated with ultra-basic rocks which are altered at least in part to serpentine. Second, the chromite is more likely to be associated with rocks rich in olivine than with rocks rich in pyroxene. The olivine-rock (dunite) is likely to be of smaller grain, more serpentinized, and unless some alteration like silicification has intervened, more weathered than the pyroxene-rock. Hence, soft spots containing abundant red-brown iron staining resulting from oxidation of iron in the olivine are favorable places for prospecting by trenching in some of the occurrences.

With the exception of the two points mentioned above, the geology of chromite deposits is complex rather than simple. Masses of ultra-basic rocks, whether in sills or dikes, are likely to include half a dozen rocks of different composition rather than a smaller number. Whether this is due to differentiation in a single magma or whether it is the result of several successive intrusions is not known at the present time. The writer has noted dikes of one basic rock in another basic rock at one or two California chromite deposits, but in nearly all bodies of ultra-basic rock, alteration is so intense that contact relations can not be distinguished. The abundant minerals in these rocks are olivine and pyroxene, both silicates of iron and magnesium but with different crystallization.

The pyroxene group includes a number of minerals that crystallize in either the orthorhombic or monoclinic system. Of those in the orthorhombic system, enstatite, $MgSiO_3$, bronzite, $(Mg,Fe)SiO_3$, and hypersthene, $(Fe,Mg)SiO_3$, are prominent rock-forming members. Of the monoclinic group, diopside, $CaMg(SiO_3)_2$, and augite, $CaMg(SiO_3)_2$ with $(Mg,Fe)(Al,Fe)_2SiO_6$ are often found in rocks. Diallage is a variety with a fibrous structure intermediate in composition between diopside and augite. All of these minerals crystallize as prisms, and the faces of the crystals are likely to be relatively large compared to other crystals in a basic or ultra-basic rock. Colors range from light shades of yellowish and greenish to dark olive-green, brown, and black, depending on the amount of iron present in the mineral. The dark colors are the most common in rocks. Luster is vitreous for most of these minerals and hardness 5 to 6 if they are fresh, but alteration to serpentine changes both of these properties.

Olivine has a chemical composition expressed by $(Mg,Fe)_2SiO_4$, in which the ratio of magnesium to iron may be anything from 16:1 to 2:1. Luster is vitreous, hardness is 6.5 to 7, and color is commonly dark olive-green or brownish. Alteration to green serpentine is common, and oxidation of the iron produces brown and red colors of iron oxides. In rocks the olivine is usually present in grains considerably smaller in size than the prisms of pyroxene. Both olivine and pyroxene alter to serpentine, and later break down into iron oxides and magnesite if circulating waters contain carbon dioxide. Silica is liberated and is likely to be found as masses of chalcedony, opal, or jasper. Outcrops of ultra-basic rocks rich in these minerals usually exhibit the green to greenish-black colors and greasy luster and feel of serpentine. The hardness of the serpentine is much less and may be as low as 2.5. Pyroxene is a little more resistant to alteration than olivine, and the outlines of the original prisms are often distinguishable in the serpentine.

The general name for these olivine-pyroxene rocks is peridotite, but this name has also been used for such rocks rich in olivine. Rocks rich in pyroxene are called pyroxenite. If olivine forms 95 percent of the rock, it is called dunite. Other names that are used for rocks composed of olivine and pyroxene are bronzite, hartzburgite, saxonite, and lherzolite.

Types of alteration that may affect these rocks are as follows: (1) serpentinization, (2) silicification, (3) the formation of talc, (4) the formation of magnesite, and (5) weathering of the iron to red and brown oxides. The alteration to serpentine is believed to follow very shortly after the crystallization of the rocks. A rather soft, yielding mass results and any pressure or folding causes faults and fractures which are likely to offset the chromite deposits, and some of the fractures may be filled by magnesite veins.

The only commercial mineral of chromium is chromite, of which the ideal chemical composition is $FeO.Cr_2O_3$, (68% Cr_2O_3) but actual analyses show that part of the iron may be replaced by magnesium and part of the chromium by aluminum or ferric iron. Chromite crystallizes in octahedrons and is commonly massive or fine granular to compact. Fracture is uneven and the mineral is brittle. Color is between iron-black and brownish black and the streak is brown. Luster is sub-metallic. Hardness is 5.5 or about the same as that of the steel in a pocket-knife. Specific gravity ranges from 4.1 to 4.9. Some lumps may have a purple or lavender cast due to the presence of alteration products, kämmererite, a chrome chlorite (sometimes peach-blossom red) or stichtite ($MgCO_3.5Mg(OH)_2:2Cr(OH)_3.4H_2O$). A rather common emerald-green coating on fractures is the chrome garnet, uvarovite. The writer has noted apple-green coatings of a nickel mineral, possibly garnierite, at the Coggins chrome mine on the Shasta-Siskiyou county line.

Chromite has been thought by many geologists to have settled out by gravity from the molten ultra-basic rocks, and some deposits are still thought to have been formed in this way. However, many deposits are not fully explained by this theory and some geologists now consider the possibility that after the chromite crystals had settled, and while the matrix was still in a fluid or semi-fluid condition, pressure forced the material rich in chromite crystals out into fractures and shear-zones in parts of the rock that had already solidified. Hydrothermal deposition is thought by some to have played a minor role. Most of the deposits in California show evidence that all of these processes have been active.

Two distinct types of chromite deposits are found in California. In one type the chromite occurs in lenses, kidneys, or pods of high grade ore that are largely chromite with little gangue. The largest of these thus far found in California produced about 20,000 tons of ore but most of them are much smaller. A few hundred tons in a single lens, kidney, or pod is more than is ordinarily found. Most of them are more likely to contain a ton or less. In the second type of ore the chromite is disseminated in small grains throughout zones in masses of peridotite or dunite. All ranges of composition from a few scattered grains of chromite to material that is principally chromite are possible. Bands an inch wide or less of rich chromite are likely to alternate with bands that are largely gangue. Bodies of such ore recently developed range in composition from 20% to 50% chromite, or in terms of chromic oxide (Cr_2O_3) from 10% to 25%. Several hundred thousand tons of such ore has recently been developed, and although milling is required to raise the grade, these deposits promise a greater tonnage of chromite at a reasonable price than the small lenses, kidneys or pods. Examples of such deposits are the Gray Eagle in Glenn County, the Pilliken in El Dorado County, and the Seiad in Siskiyou County.

The original deposition of chromite appears to have been quite erratic and the fracturing and faulting commonly found in bodies of serpentine add to the difficulty of following orebodies. The fractures and faults have cut the orebodies into small detached segments in many places. A mantle of surface debris commonly obscures the underlying rocks. Hence as soon as preliminary investigation indicates that the expense is justified, further geologic study to determine ore-reserves

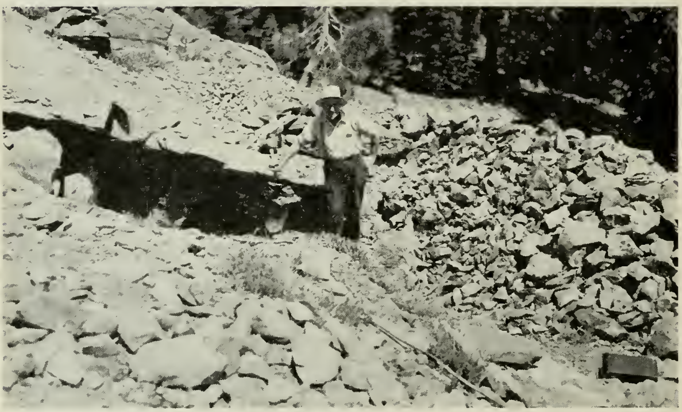

FIG. 1. Lens-type of chrome deposit, Sierra County, held by R. C. Zaring, Downieville. Shadow of pick falls on hangingwall of lens. Pile to right is chrome ore.

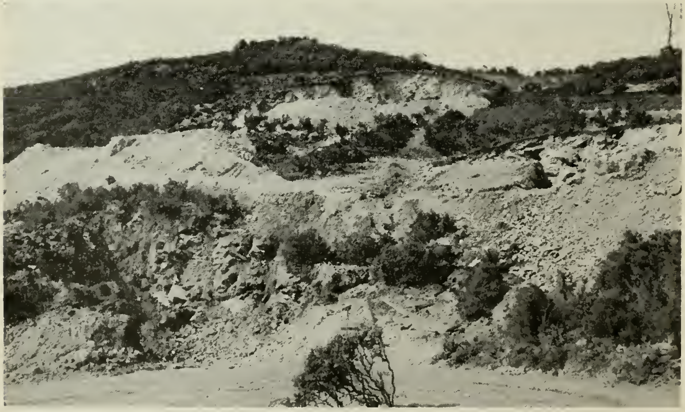

FIG. 2. Disseminated type of chrome deposit, El Dorado County, operated by Rustless Mining Corporation, Sacramento. Bulldozer is working at right of highest pit.

should be accompanied by trenching either by hand or with a bulldozer, diamond drilling, and perhaps underground development openings.

The geology of California chromite deposits has recently been described by Allen[9] and individual deposits have been described in Bulletin 76[10] of this division as they appeared during the war period 1914-18. This bulletin is still available. However the U. S. Geological Survey has recently made new studies of a number of deposits.[11] Work has been done on the disseminated type of deposit rather than the type containing small lenses of high-grade ore, because the disseminated deposits seem to hold out promise for a better tonnage of ore at a reasonable cost. To aid persons who are attempting to find new deposits of disseminated ore the following general description of the Pilliken deposit, El Dorado County, is abstracted from U. S. Geol. Survey Bulletin 922-0:

GEOLOGY OF PILLIKEN DEPOSIT

The Pilliken deposits in sec. 21, 22, T. 11 N., R. 8 E., M. D. M., occur in a tabular, steeply dipping body of ultrabasic rock, commonly called serpentine, shown in the Sacramento[12] folio as lying west of Salmon Falls. The mass is three-quarters of a mile wide and four miles long, trends north-northwestward, and dips steeply to the east. The serpentine is surrounded by hornblende and chlorite schists, described in the Sacramento folio as amphibolite schist, except at the northwest end, where it is cut off by a large mass of granodiorite. The serpentine mass is cut by two groups of diorite dikes.

The rocks collectively called serpentine consist of several varieties of ultrabasic rocks and their alteration products. The types recognized in the Pilliken area are dunite, lherzolite, pyroxenite, and metadiorite. Their most abundant and pervasive alteration product is the mineral serpentine, but especially intense alteration has changed them locally to masses consisting mainly of silica, talc, or magnesite.

DUNITE

The largest bodies of dunite are in the western part of the peridotite mass, but many thin layers and small irregular bodies of dunite are found elsewhere. The contacts of dunite with other rocks, including siliceous masses probably derived in part from dunite, are very intricate. Gradations between dunite and pyroxenite add to the difficulty of mapping the contacts, and although the lherzolite shades toward dunite in many places, only a few areas of rock are rich enough in olivine to be classed as dunite. The dunite has been so generally altered that little if any of it is entirely fresh.

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[9] Allen, J. E., Geologic Investigation of the Chromite Deposits of California: State Mineralogist's Report 37, pp. 101-167, 1941. (Bibliography, pp. 165-167.)

[10] Bradley, W. W.; Hugenin, Emile; Logan, C. A.; Tucker, W. B.; Waring, C. A., Manganese and chromium in California: California State Division of Mines Bull. 76, pp. 101-228, 1918.

[11] Rynearson, G. A., and Smith, C. T., Chromite deposits in the Seiad quadrangle, Siskiyou county, California: U. S. Geol. Survey Bull. 922-J, pp. 281-306, 1940.

Peoples, J. W., and Howland, A. L., Chromite deposits of the eastern part of the Stillwater complex, Stillwater county, Montana: U. S. Geol. Survey Bull. 922-N, pp. 371-416, 1940.

Wells, F. G., Page, L. R., and James, H. L., Chromite deposits of the Pilliken area, El Dorado county, California: U. S. Geol. Survey Bull. 922-0, pp. 417-460, 1940.

[12] Lindgren, Waldemar, and Turner, H. W., U. S. Geol. Survey Geol. Atlas, Placerville, Sacramento, and Jackson folio reprints (nos. 3, 5, and 11), p. 4, 1894, reprinted 1914.

Fresh dunite consists almost entirely of olivine, a mineral of characteristic dark olive-green color; but the freshest observed in this district is slightly serpentinized, and is dark yellowish green, with a glassy to greasy luster on fresh fracture and a buff to brown color where weathered. It is granular and fine- to medium-grained. Almost everywhere at least a few subhedral to euhedral grains of chromite are scattered through it. With increasing serpentinization the rock becomes lighter-colored, and in some places it is yellow or even white. Narrow veinlets of greenish- or brownish-yellow serpentine have pervaded the entire ultrabasic mass, cutting across both the dunite and the associated chromite.

The dunite grades, by increase of pyroxene content, into lherzolite and pyroxenite. Rock containing less than about 5 percent of pyroxene is classed as dunite, but very little of the dunite contains any pyroxene or any recognizable alteration products of pyroxene.

LHERZOLITE

The eastern two-thirds of the area is underlain by more or less altered rocks that are provisionally called lherzolite; small patches of the same rocks occur in the southern part of the area.

Lherzolite, by definition, is a granular rock composed chiefly of olivine and containing both orthorhombic and monoclinic pyroxene as essential constituents. Before it was altered, the rock in the Pilliken area that is here called lherzolite consisted mainly of olivine, with which a smaller proportion of pyroxene was associated. The nature of the pyroxene is in most places uncertain, because most of it has been completely replaced; but both the orthopyroxene, enstatite, and the clinopyroxene, diallage, have been found here and there, either separately or together. Some of the olivine-pyroxene rock, therefore is almost certainly lherzolite, and this name seems to be the most suitable, if only one name is to be used, to apply to all of this rock. It is possible, however, and even probable, that some saxonite—olivine-enstatite rock—is present. In hand specimen the freshest lherzolite resembles fresh dunite, and the color of the rock is not much altered by weathering. It is distinguished in weathered ledges by the presence of rectangular crystals of pyroxene, which have been altered to a white or pale-green silky mineral. The olivine in the lherzolite, like that in the dunite, is more or less altered to serpentine.

Most of the alteration of the lherzolite has produced talc as well as serpentine. The talc-bearing rocks are of two fairly distinct types. One is a schistose, silicified, talcose serpentine, weathering into platy pinnacles, which occurs in the southeastern part of the lherzolite area. In this rock the pyroxene crystals characteristic of lherzolite are still recognizable, although they have been completely altered and much distorted. The second type includes talc schist and massive talc rocks.

Some of the lherzolite has been so thoroughly silicified as to form fairly large jasperoid masses. In some of this rock the texture is completely destroyed, although some distorted and altered pyroxene crystals are recognizable as whitish patches, elongated parallel to shear zones, in a brown, fine-grained groundmass.

Very little high-grade chromite was noted in the lherzolite itself, but some is found in narrow dunite bands in the gradational zones.

The northeastern part of the open pit east of the shaft in East Basin is in a rock that appears, strictly speaking, to be lherzolite, although it is very close to dunite in composition. The rock in general contains about 5 percent of pyroxene; but it contains a streak of rather high-grade disseminated chromite (apparently over 20 percent), which probably extends for some distance to the north and south.

PYROXENITE

Most of the pyroxenite occurs in the southwestern part of the area, as small irregular masses associated with dunite and silicified rocks. The largest single body crops out around the common corner of sections 20, 21, 28, and 29, in a roughly oval area, which lies between two bands of metamorphic rocks but is separated from them on the west by a thin band of dunite. A small patch of dunite was noted, also, on the southeast side.

Two small patches of pyroxenite occur in the northern part of the area, both of them near areas rich in chromite. Southeast of the large mass and north of the northeast-southwest fault are several patches of pyroxenite, which appear to have been parts of north-trending bands until they were separated by the formation of jasperoid and silicified zones. South of the fault a rather large area of pyroxenite appears to trend northeast-southwest, parallel to the pyroxenite bands in the nearby gradational zone. The boundaries of this mass are so irregular and angular as to suggest that its present shape and position resulted from shearing and faulting. This mass is unique in its rather broad border of lherzolite in which bands of pyroxenite as much as a foot or more in width are common.

The pyroxenite is a coarse-grained dark-gray to greenish-black rock consisting almost entirely of diallage. It is locally altered by shearing to a green talcose-chlorite schist. Where zones of silicification cross the pyroxenite, it is altered to a dark-brown jasperoid, which contains very little or no chromite.

In texture and other features the pyroxenite is rather uniform. The average grain size is about half an inch, although there are some isolated patches of pyroxene crystals as much as an inch in diameter. In two places near the north end of the area are pegmatitic rocks that are more than half pyroxene; they contain 2-inch pyroxene crystals in an apparently feldspathic groundmass.

In weathering, the pyroxenite loses its greenish color and becomes gray to black; it is slightly iron-stained in places. Being more resistant to weathering than most of the other rocks in the area, it is commonly well exposed and forms several hills. The soil derived from the pyroxenite supports a characteristic thick growth of chamisal.

HYDROTHERMAL ALTERATION

Serpentinization

Serpentinization is so general in the peridotites that practically none of the dunite or lherzolite is wholly free from serpentine. Olivine is the mineral chiefly affected; pyroxene is not attacked until the olivine has been largely replaced. The original character of the rock may often be apparent even after serpentinization has been complete;

for olivine alters to aggregates of flakes and fibers in random orientation, which are dark green and lusterless, whereas the pyroxenes alter to pseudomorphs consisting largely of parallel fibers, the luster of which readily catches the eye. Where movement along fractures has occurred, and in schists, the serpentine fibers throughout the rock tend to lie parallel to the fractures or the foliation; but the serpentine fibers in veinlets that fill tension cracks lie at right angles to the walls.

Silicification

Silicified zones are highly characteristic of the area and are of economic interest because the silicified rock is difficult to crush. Nearly all of the silicified zones are in ultrabasic rock, only one or two poorly developed narrow ones having been observed in the metamorphic rocks.

The silicified rocks grade from slightly silicified dunite, lherzolite, or pyroxenite to jasper. The jasper is a dense, fine-grained, usually brownish rock that breaks with a smooth conchoidal fracture. It is strongly resistant to weathering and commonly forms jagged outcrops. Less silicified rock weathers to a rough cellular mass.

Talc Schist

Some of the talc schist probably was derived from dunite, some from lherzolite, and some from pyroxenite. The rock is especially abundant in and around the main mass of lherzolite, but that derived from lherzolite and that derived from dunite are almost indistinguishable. Except where silicified, the talc schist is white to gray and very soft. Pits and other workings have been dug in chromite-rich portions of the talcose zones, and their distribution suggests that the chromite-bearing talc schist was derived from dunite. Some of it, in fact, contains recognizable remnants of dunite.

The cleavage in the talc zones is apparently a shear cleavage developed over a large area. Talc schist has been formed along the great fault in section 28 where both walls are of ultrabasic rock.

Magnesite

Creamy-white fine-grained compact magnesite forms veins, and irregular masses of it have replaced dunite, especially that which is highly fractured and rich in chromite. It is associated with veins of chalcedony and opal. The magnesite veins are best exposed in the open-pit workings of West Basin. Two of the veins here are about 3 feet thick and are laminated. In the shaft area magnesite replaces dunite but not the serpentine veinlets and chromite within it.

MINERALS OF ORE DEPOSITS

The chromite from the Pilliken area varies in composition from place to place, containing from 45% to 50% of chromic oxide and from 16% to 20% of metallic iron. The purple chromium chlorite, kämmererite, and green chromium garnet, uvarovite, are present in very minor amount.

Serpentine, talc, and magnesite veinlets cut the ore bands. The gangue minerals are olivine ($(Mg,Fe)SiO_2$), serpentine ($H_4Mg_3Si_2O_9$), magnesite ($MgCO_3$), and talc ($H_2Mg_3(SiO_3)_4$), with chert or other siliceous material in the silicified zones. Most of these are alteration products or were introduced, so the character of the ore differs greatly in different areas and even in different parts of the same pit. Weathering produces a 'soft' ore which, if wet, clogs the crusher. 'Hard' unweathered ore, with a gangue consisting largely of olivine or silica, sustains high losses because of sliming.

TEXTURE OF ORES

Disseminated chromite grains are distributed throughout the dunite in concentrations of less than 0.5% to more than 30%. Disseminated chromite in lherzolite rarely exceeds 1% of the rock, although it may be more highly concentrated in enclosed thin lenses of dunite. Most of the disseminated grains have more or less definite crystal form, but some are rounded at the corners as if corroded. Some grains are rounded at one end but not at the other, and many are completely rounded. Some clusters of irregular grains appear to have filled up spaces between crystals of other minerals; some have the shapes of coalescing globules. Some grains have curved cracks, which may indicate that they grew from a rounded nucleus. Chromite grains of all shapes enclose gangue minerals and are enclosed by them. Some grains in sheared rocks have eyelike outlines and tail out into thin streaks of dust along the foliation.

The disseminated grains are far from uniform in size, and in general they are largest where they are most abundant. In rock that contains less than 1% of chromite the grains are usually less than 1 millimeter in diameter.

The average tenor of the disseminated ores where they are exposed in trenches and shovel pits is rarely over 10%, but in many places the disseminated ore encloses thin lenses of much higher tenor. The lenses are of three types: (1) those consisting almost entirely of chromite and sharply bounded on both sides, (2) those sharply bounded on the lower, or west, side and having gradational boundaries on the upper, or east, side, and (3) those having gradational boundaries on both sides. In any one area the three types may be about equally common or one type may predominate. Individual rich layers range from a fraction of an inch to 4 feet in thickness. They may pinch out either gradually or abruptly, or frazzle out into streaks of disseminated grains. Pinching and swelling along the strike is characteristic and may result in a series of small sharply-bounded lenses or pods. As a rule the rich layers have sharper boundaries where disseminated grains are sparse than where they are more abundant.

The chromite streaks, except where disturbed by later deformation, are parallel to the walls of the dunite masses. Individual lenses are erratically distributed and discontinuous, but some zones made up of many lenses, such as those in the shaft and shovel-pit areas of East Basin, persist for a considerable distance.

Texturally, bands that are moderately rich but contain much silicate are similar to those in which the grains are more sparsely disseminated. Grains showing crystal faces are less common and rounded grains more common in the rich bands than in disseminated ore, and where chromite makes up the entire band the individual grains are intergrown. The forms outlined by serpentine that has been introduced along grain boundaries and cracks without replacement are angular in part, but a surprisingly large proportion of them are bounded by cracks.

Nodular ore, locally known as 'leopard' or 'grape' ore, is found north of Chrome Gulch, and its occurrence in the workings of the Chrome Placer Co., in the NW¼ sec. 21, has been described by Diller.[13] In the SE¼ sec. 21 chromite nodules are associated with disseminated grains and irregular bands of chromite. The spheroidal or ellipsoidal masses of chromite in the nodular ore are sharply bounded. In some places they are separate but elsewhere they are grown together, leaving small interstices filled with olivine or serpentine or both. Grains of these silicates are also enclosed in the nodules. No thin sections of the nodular ore from the Pilliken area have been examined, but one of Diller's sections of material from Briggs Creek, Oregon, shows the boundary of a nodule to be sharp, though roughened by projecting grains of chromite partly bounded by crystal faces. The chromite grains, outlined by introduced serpentine, within the orbicules are anhedral, owing to mutual interference during growth.

LOCALIZATION

The most outstanding fact regarding the localization of the chromite ore is that it is all in dunite. Some prospect pits in lherzolite show concentrations of chromite, but probably all of these prospects are in lenses of dunite at most a few feet thick. No large orebodies are likely to be found in such environments.

A few streaks in the dunite masses may contain enough disseminated chromite to be minable. These streaks are, in general, parallel and near to contacts between dunite and pyroxenite. Chromite has not been formed at the contacts of dunite with the schists. Massive chromite ore containing from 40% to 50% of chromic oxide, which may be mined and sold directly, can be obtained only from fairly thick layers of nearly solid chromite. Most of the milling ore comes from zones in which groups of discontinuous bands of massive chromite are associated with disseminated chromite. It is mined both from open pits and from underground workings. These zones lie parallel to the trend of the enclosing dunite masses, and they are fairly persistent, though they are so much broken by small faults that individual bands can not easily be followed. The minable width of these zones is determined by the grade of ore desired.

More than one ore zone may occur in any single mass of dunite just as more than one band of dunite may occur in any one peridotite area.

Field relations indicate that these are reasonable guides to prospecting, but they must be used in conjunction with the knowledge that the original orebodies have been highly fractured, faulted, sheared, and silicified. Only in undisturbed areas do the chromite bands trend parallel in strike and dip to the nearest dunite boundary.

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[13] Diller, J. S., Chromite in the Klamath Mountains, California and Oregon: U. S. Geol. Survey Bull. 725, p. 12, 1921.

PROSPECTING

The high specific gravity of chromite is a great aid to the prospector. A lump of chromite is nearly twice as heavy as a lump of the same size of rocks associated with it. The chromite float lying on the surface of the ground is likely to be stained reddish brown by a coating of iron oxide, and associated rocks often have a similar color. However the prospector needs only to lift the chunk of chromite to detect the weight. The chunks of chromite are likely to exhibit rounded forms and rounded corners in contrast to angular forms of fragments of associated rocks. The chromite also has a smoother surface. The high specific gravity also allows detection of small grains in the miner's gold pan.

Probably nothing has contributed more to recent success in prospecting for chromite than the tractor and bulldozer used for trenching. It is not a cheap method as such a machine is likely to cost $4.00 per hour to operate. Hence money can be saved by a careful selection of ground to be trenched. Examination of the surface for chromite float and panning for small grains are helpful.

A simple chemical test for chromium is made by fusing in a loop of platinum wire a salt of phosphorous (sodium-ammonium phosphate) bead before a blowpipe and taking into the molten bead a grain or two of the powdered mineral to be tested. A green color is obtained if chromium is present. A similar test can be made with borax, but the resulting bead is yellow in the oxidizing part of the flame, and this may cause confusion. When chromite is rubbed on a piece of unglazed porcelain, it leaves a dark brown mark or streak. This is a useful field-test because dark pyroxenes and serpentines give a white or nearly white streak.

OUTLOOK FOR CALIFORNIA

At the present time all of the chromium steels made in the United States are made in eastern states. Hence chromium produced in California must be shipped to the East either as ore, concentrate, or ferrochrome. Chromium used in steels for airplanes, automobiles, and tractors made in California must be shipped back from the East. The time will no doubt come when this long round-trip for the chromium will no longer be necessary. Power should be available for electric furnaces to manufacture chromium steels in California, and the establishment of factories for turning out parts for airplanes, engines, automobiles and tractors in California should follow. California chrome ore is likely to be in great demand for the duration of the war. Possibly California chrome ore will again be driven from the market by cheaper foreign ores; but even so, imported chrome ore will be available at Pacific ports as well as Atlantic ports.

ADMINISTRATIVE

WALTER W. BRADLEY, State Mineralogist

PERSONNEL

There were no changes in personnel during the past three months to be noted.

NEW PUBLICATIONS

COMMERCIAL MINERAL NOTES (Nos. 220, 221, 222) August, September, October, 1941, respectively. These 'Notes' contain the list of 'mineral deposits wanted' and 'mineral deposits for sale,' issued in the form of a mimeographed sheet monthly. It is mailed free to those on the mailing list for 'California Journal of Mines and Geology.' As an evidence of the interest in mines and mineral resources now showing considerable activity, this mimeographed 'sheet' has had to be expanded to five pages in recent months.

MAIL AND FILES

The Division of Mines maintains, in addition to its correspondence files and the library, a mine file which includes original reports on the various mines and mineral properties of all kinds in California.

During each quarterly period there are several thousand letters received and answered at the San Francisco Office alone, covering almost every phase of prospecting, mining and developing mineral deposits, reduction problems, marketing of refined products and mining law. In addition to this, hundreds of oral questions are answered daily, both at the main office and the district offices, for the many inquirers who come in for personal interviews and to consult the files and library.

MINERALS AND STATISTICS

Statistics, Museum

HENRY H. SYMONS, Statistician and Curator

STATISTICS

California Mineral Production for 1941

The total value of the mineral production of California for the year 1941, just closed, is conservatively estimated by the Statistical Section to be $367,784,000. This is partly detailed in the tabulation below, but as there are more than 60 mineral substances on California's commercial list, figures on the most important items only are available at this early date. The production report forms are being mailed to the operators in all mineral lines, and the detailed and completed report will be compiled and published later.

The estimated total of $367,784,000 is an increase of approximately $24,958,000 over the 1940 total value. The principal substances showing increases in value over the previous year were petroleum, cement, tungsten, quicksilver, miscellaneous stone, natural gas, lead, brick, and the industrial minerals group. Important minerals to register a decreased value were gold, copper, silver, and the saline group.

Petroleum output showed an increase of about 9,000,000 barrels in amount and about 6 percent in value over that of the previous year. The estimated quantity of crude oil was 230,157,000 barrels for 1941. There was an increase in the price paid to producers by the refineries starting in March. Natural gas showed an increase in both amount and value of that utilized compared with 1940.

Reports of the mint and smelters show the output of gold to be less than in 1940. The State's yield of tungsten, quicksilver, lead, zinc, chromite, manganese showed marked increases during the year, while copper, gold, and silver showed decreases. The output of quicksilver, tungsten, and silver each exceeded the million dollar mark as well as gold.

Of the structural group, cement, miscellaneous stone, brick, and magnesite all showed increases in amount and value over that of 1940. The cement production was the largest in the history of this industry in California; and for the first time all the plants approached capacity output. Under the miscellaneous industrial mineral group, stimulated business conditions and national defense increased the demand for many substances included in this classification so as to make it show a marked increase in total value. The saline group was the only group to show a decreased value for 1941; this was not brought about by lack of demand for minerals included under this classification but by one of the largest operators of these materials being shut down for three months by labor trouble.

The estimated values and quantities for 1941 are as follows:

$49,420,000	(1,412,000 fine ounces) Gold.
1,527,000	(2,147,000 fine ounces) Silver.
913,000	(7,810,000 pounds) Copper.
370,000	(6,610,000 pounds) Lead.
4,233,000	(23,500 flasks) Quicksilver.
3,450,000	(150,000 units) Tungsten Ore.
425,000	Other metals, including chromite, manganese ore, iron ore, platinum metals, antimony, titanium, zinc, etc.
220,260,000	(230,157,000 barrels) Petroleum.
21,055,000	(363,025,000 M. cu. ft.) Natural Gas.
27,531,000	(19,950,000 barrels) Cement.
14,000,000	Crushed rock, sand, and gravel.
3,200,000	Brick and hollow building tile.
2,100,000	Other structural materials, including bituminous rock, granite, lime, magnesite, marble, sandstone, slate.
7,100,000	Miscellaneous industrial materials.
12,200,000	Salines, including borates, potash, iodine, salt, soda, and others.
$367,784,000	Total value.

LABORATORY

George L. Gary, Mineral Technologist

Since 1866 many lists have been published showing localities of California minerals. The last one, "Minerals of California," by Adolph Pabst, was published in 1938 by the Division of Mines as Bulletin No. 113.

It is the intention of the Division of Mines to publish in the quarterly new localities for minerals that are received by the laboratory for determination. So that this information may be accurate, it is requested that all specimens submitted for classification be accompanied by a letter giving the exact location where the material was found.

Corrections will also be noted as well as additions when called to our attention.

CORRECTIONS AND ADDITIONS TO BULLETIN 113

115. **Anglesite,** $PbSO_4$, lead sulfate crystals associated with galena was reported from Calaveras County.

116. **Foliated massive Orpiment,** As_2S_3, has been reported from Kern and Siskiyou Counties.

End of January, 1942.

LIBRARY

HENRY G. HUBBARD, Librarian

In addition to the numerous standard works, authoritative information on many phases of the mining and mineral industry is constantly being issued in the form of reports and bulletins by various government agencies.

The library of the Division of Mines contains over six thousand selected volumes on mines, mining and allied subjects, and it is also a repository for reports and bulletins of the technical departments of Federal and State governments and of educational institutions, both domestic and foreign.

It is not the dearth of the latter publications, but rather a lack of knowledge of just what has been published and where the reports may be consulted or obtained, that embarrasses the ordinary person seeking specific information.

To assist in making the public acquainted with this valuable source of current technical information, CALIFORNIA JOURNAL OF MINES AND GEOLOGY contains under this heading a list of all books and official reports and bulletins received which pertain particularly to mining in California.

Files of all the leading technical journals will be found in the library, and county and State maps, topographical sheets and geological folios. Current copies of local newspapers published in the mining centers of the State are available for reference.

The library and reading room are open to the public during the usual office hours, when the librarian may be freely called upon for all necessary assistance.

OFFICIAL PUBLICATIONS RECEIVED WHICH HAVE SPECIAL INTEREST OR REFERENCE TO CALIFORNIA

Governmental, National

U. S. Geological Survey
  Bulletins
    922-L Quicksilver Deposits of the Mayacmas and Sulphur Bank Districts, California.
    922-O Chromite Deposits of the Pilliken Area, El Dorado County, California.
    922-Q Tungsten Deposits in the Tungsten Hills, Inyo County, California.
    922-R Quicksilver Deposits in San Luis Obispo and Monterey counties, California.
    922-S Tungsten Deposits of the Benton Range, Mono County, California.
    925-D Geophysical Abstracts—October-December, 1940.
    927-A Superposition in the Interpretation of Two-Layer Earth Resistivity Curves.
    931-B Some Quicksilver Prospects in Adjacent Parts of California, Nevada and Oregon.
    932-A Geophysical Abstracts, January-March, 1941.
    914 (Correction Sheet) Microscopic Determination of the Ore Minerals.
  Water Supply Papers
    868-A Investigations of Methods and Equipment used in Stream Gaging (Part 1).

868-B Investigations (Part 2).
879 U. S. Surface Water Supply (Part 9) Colorado River Basin.
Topographic Maps
Devore Quadrangle, San Bernardino County.
Firebaugh Quadrangle, Fresno and Madera counties.
Ontario and Vicinity Quadrangle, San Bernardino County.
Prado Quadrangle, San Bernardino, Riverside and Orange counties.
Gausti and Vicinity Quadrangle, San Bernardino and Riverside counties.
Swarthout Quadrangle, Los Angeles County.
Waterman Mountain Quadrangle, Los Angeles County.
Professional Paper
195 Geology of the Kettleman Hills Oil Field, California.
U. S. Bureau of Mines
Bulletins
431 Mechanical Concentration of Gases.
437 Coal Mine Accidents in the U. S., 1938.
438 Quarry Accidents in the United States, 1939.
439 Some Essential Safety Factors in Tunneling.
440 Metal and Nonmetal Mine Accidents in the U. S., 1939.
Technical Papers
632 Theoretical calculations for explosives.
Report of Investigations
No. 3564; 3567; 3569; 3570, 3571; 3574; 3576; 3578; 3580; 3582-3584; 3589.
Information Circulars
6884-R; 7164; 7169-7174; 7177; 7179; 7182-7183.
U. S. Geological Survey
Bulletins, Water Supply Papers, Topographic Maps, Professional Papers.
U. S. Bureau of Mines
Bulletins, Technical Papers, Report of Investigations, Information Circulars, Miners Circulars.

PUBLICATIONS RECEIVED CURRENTLY AND FORMER REPORTS AVAILABLE FOR REFERENCE

Governmental, State

Alabama Geological Survey, University.
Alaska (Territorial Commissioner of Mines), Juneau
Arizona Bureau of Mines, Tucson.
Arkansas Geological Survey, Little Rock.
Colorado Bureau of Mines, Denver.
Connecticut Geological and Natural History Survey, Hartford.
Florida Department of Conservation, Tallahassee.
Georgia Division of Geology, Atlanta.
Idaho Bureau of Mines and Geology, Moscow.
Illinois Geological Survey, Urbana.
Indiana Division of Geology, Indianapolis.
Iowa Geological Survey, Des Moines.
State Geological Survey of Kansas, Lawrence.
Kentucky Geological Survey, Frankfort.
Louisiana Department of Conservation, New Orleans.
Maine State Geologist, Augusta.
Maryland Geological Survey, Baltimore.
Michigan Geological Survey, Lansing.
Minnesota Geological Survey, Minneapolis.
Mississippi State Geological Survey, University.
Missouri Bureau of Geology & Mines, Rolla.
Montana Bureau of Mines and Geology, Butte.
Nebraska Geological Survey, Lincoln.
Nevada State Bureau of Mines, Reno.
New Jersey Department of Conservation and Development, Trenton.
New Mexico Bureau of Mines and Mineral Resources, Socorro.
New York Science Division, Albany.
North Carolina Geological & Economic Survey, Chapel Hill.
North Dakota Geological Survey, Grand Forks.
Ohio Geological Survey, Columbus.

Oklahoma Geological Survey, Norman.
Oregon State Department of Geology and Mineral Industries, Portland.
Pennsylvania Topographic and Geological Survey, Harrisburg.
South Dakota State Geological Survey, Vermillion.
Tennessee Division of Geology, Nashville.
Texas Bureau of Economic Geology, Austin.
Virginia Geological Survey, University.
Washington State Department of Conservation and Development, Pullman.
West Virginia Geological Survey, Morgantown.
Wisconsin Geological & Natural History Survey, Madison.
Wyoming Geological Survey, Cheyenne.

Governmental, Foreign

Alberta Research Council, Edmonton.
Argentina Direccion General de Minas y Geologica, Buenos Aires.
British Columbia Minister of Mines, Victoria.
British Museum and Natural History, London.
Canada Department of Mines, Ottawa.
Cuerpo de Ingenieros de Minas y Aguas del Peru, Lima.
Geological Service of Minas Geraes, Bella Horizonte, Brazil.
Geological Survey of Scotland.
Instituto Historica e Geographico Rio de Janeiro.
Museo de Historia Natural de Montevideo, Uruguay.
New South Wales Department of Mines, Sydney, Australia.
New Zealand Geological Survey Branch, Wellington.
Nova Scotia Department of Public Works and Mines, Halifax.
Ontario Department of Mines, Toronto, Canada.
Quebec Bureau of Mines, Quebec.
Queensland Department of Mines, Brisbane, Australia.
South Australia Department of Mines, Adelaide.
Transvaal Chamber of Mines, Johannesburg, South Africa.
Western Australia Geological Survey, Perth.

Societies and Educational Institutions

Academia de Ciencias y Artes de Barcelona, Spain.
Academy of Natural Sciences of Philadelphia.
American Association of Petroleum Geologists, Tulsa, Oklahoma.
American Geographical Society of New York.
American Institute of Mining and Metallurgical Engineers, New York.
American Journal of Science, New Haven, Conn.
American Philosophical Society, Philadelphia.
Australian Museum, Sydney.
California Academy of Sciences, San Francisco.
Canadian Institute of Mining and Metallurgy, Montreal.
Carnegie Institution of Washington.
Cleveland Museum of Natural History, Cleveland, Ohio.
Colorado College Publications, Colorado Springs.
Colorado Scientific Society, Denver.
Commonwealth Club, San Francisco.
Economic Geology, Lancaster, Pa.
Field Museum of Natural History, Chicago.
Franklin Institute of the State of Pennsylvania, Lancaster.
Geological Society of America, Columbia University, New York.
Geographical Society of London.
Institution of Mining and Metallurgy, London.
Instituto Geologico de Mexico, Mexico, D. F.
Journal of Geology, Chicago.
Mineralogical Society of America, Menasha, Wisconsin.
Michigan College of Mining and Technology, Houghton.
Mining and Metallurgical Society of America, New York.
Missouri School of Mines and Metallurgy, Rolla.
Museu Nacional, Rio de Janeiro.
National Research Council, Washington, D. C.
New York Academy of Sciences, New York.
New York State Museum. Albany.

Pennsylvania State College, State College.
Philippine Journal of Science, Manila.
Royal Society of South Australia, Adelaide.
Seismological Society of America, Stanford University.
Sierra Club, San Francisco.
Society of Economical Paleontologists and Mineralogists, Fort Worth, Texas.
Southern California Academy of Sciences, Los Angeles.
Stanford University, Palo Alto, California.
University of California Publications in Engineering, Berkeley.
University of California Publications in Geography, Berkeley.
University of California Publications in Geology, Berkeley.
University of Harvard, Department of Mineralogy and Petrography, Cambridge, Mass.

Current Magazines on File

For the convenience of persons wishing to consult the technical magazines in the reading room, a list of those on file is appended:

Asbestos, Philadelphia, Pennsylvania.
Brick and Clay Record, Chicago.
California Journal of Development, San Francisco.
California Mining Journal, Auburn.
California Oil World, Los Angeles.
California Safety News, San Francisco.
Canadian Mining Journal, Gardenvale, Quebec.
Chemical and Metallurgical Engineering, New York City.
Chemical Engineering and Mining Review, Melbourne, Australia.
Civil Engineering, New York City.
Colorado School of Mines, Golden, Colorado.
Engineering and Mining Journal, New York City.
Fuel Oil, Chicago, Illinois.
Fusion Facts, Whittier, California.
Gold, Toronto, Canada.
Grizzly Bear, Los Angeles.
Hercules Mixer, Wilmington, Delaware.
Independent Monthly, Tulsa, Oklahoma.
Lubrication, The Texas Co., New York City.
Metals and Alloys, Pittsburgh, Pennsylvania.
Mine and Mill World Digest, San Francisco.
Mining and Contracting Review, Salt Lake City.
Mineralogist, Portland, Oregon.
Mining Congress Journal, Washington, D. C.
Mining and Industrial News, San Francisco.
Mining and Geological Journal, Melbourne, Victoria, Australia.
Mining Journal, London.
Mining Journal, Phoenix, Arizona.
Mining and Metallurgy, New York City.
Mining Review, Salt Lake City.
Mining World, Seattle.
Nevada Mining Bulletin, Las Vegas, Nevada.
Nickel Steel Topics, New York City.
Northwest Mining, Spokane, Washington.
Northwest Science, Cheney, Washington.
Oil and Gas Journal, Tulsa, Oklahoma.
Oil, Paint and Drug Reporter, New York City.
Oil Weekly, Houston, Texas.
Pacific Purchaser, San Francisco.
Pacific Chemical and Metallurgical Industries, San Francisco.
Petroleum World, Los Angeles.
Queensland Government Mining Journal, Brisbane, Australia.
Rock Products, Chicago.
Rocks and Minerals, Peekskill, New York.
Scientific American, New York City.
Southwest Builder and Contractor, Los Angeles.
Stabilizer, Los Angeles.

Standard Oil Bulletin, San Francisco.
Stone, New York City.
Western Mining News, San Francisco.

Newspapers

The following papers are received and kept on file in the library:

Alaska Weekly, Seattle, Washington.
Amador Dispatch, Jackson, California.
Banner, Sonora, California.
Barstow Printer, Barstow, California.
Bridgeport Chronicle-Union, Bridgeport, California.
Calaveras Californian, Angels Camp, California.
Calaveras Prospect, San Andreas, California.
Colusa Sun-Herald, Colusa, California.
Courier Free Press, Redding, California.
Daily Commercial News, San Francisco, California.
Del Norte Triplicate, Crescent City, California.
Denver Mining Record, Denver, Colorado.
Georgetown Gazette, Georgetown, California.
Humboldt Beacon, Humboldt.
Inyo Independent, Independence, California.
Inyo Register, Bishop, California.
Las Vegas Age, Las Vegas, Nevada.
Livermore Herald, Livermore, California.
Los Angeles Times, Los Angeles, California.
Mariposa Gazette, Mariposa, California.
Mercury Register, Oroville, California.
Mining Press, Reno, Nevada.
Mohave Miner, Kingman, Arizona.
Mojave-Randsburg Record, Mojave, California.
Morning Union, Grass Valley, California.
Mountain Messenger, Downieville, California.
Needles Nugget, Needles, California.
Nevada Mining Bulletin, Las Vegas, Nevada.
Oil Marketer, Bayonne, New Jersey.
Owens Valley Press-Citizen, Lone Pine, California.
Placer Herald, Auburn, California.
Plumas Independent, Quincy, California.
Randsburg Times, Randsburg, California.
Shasta Courier, Redding, California.
Stockton Record, Stockton, California.
Tehachapi News, Tehachapi, California.
Terra Bella News, Terra Bella, California.
Tuolumne Independent, Sonora, California.
Tuolumne Prospector, Tuolumne, California.
Union Democrat, Sonora, California.
Ventura County News, Ventura, California.
Waterford News, Waterford, California.
Weekly Trinity Journal, Weaverville, California.
Western Mineral Survey, Salt Lake City, Utah.
Western Sentinel, Etna Mills, California.
Yreka Journal, Yreka, California.

New Books:

1. Fluorescent Light by Dake & DeMent (1941).
2. Minerals Year Book (Review of 1940) U. S. Bureau of Mines.
3. Crater Lake by Howell Williams (1941).
4. Report of Electro-thermic Reduction Process for Magnesium, by Todd-Calif. Shipbuilding Corporation (1941).
5. Petroleum World Annual Review (1941).
6. The Condensed Chemical Dictionary by Reinhold Publishing Corp. (1942).
7. Uranium and Atomic Power, by Dake & DeMent (1941).
8. Fluorescent Chemicals, by Jack DeMent (1942).
9. Mining Engineers Handbook (in 2 Vols.) by Robert Peele, 3rd Edition (1941).
10. The Mineral Industry During 1940, by C. A. Roush (1941).

PRODUCERS AND CONSUMERS

The producer and consumer of mineral products are mutually dependent upon each other for their prosperity, and one of the most direct aids rendered by this Division to the mining industry in the past has been that of bringing producers and consumers into direct touch with each other.

This work has been carried on largely by correspondence, supplemented by personal consultation. Lists of buyers of all the commercial minerals produced in California have been made available to producers upon request, and likewise the owners of undeveloped deposits of various minerals, and producers of them, have been made known to those looking for raw mineral products.

When the publication of *Mining in California* was on a monthly basis, current inquiries from buyers and sellers were summarized and lists of mineral products or deposits 'wanted' or 'for sale' included in each issue.

It is important that inquiries of this nature reach the mining public as soon as possible and in order to avoid the delay incident to the present quarterly publication of CALIFORNIA JOURNAL OF MINES AND GEOLOGY, these lists are now issued monthly in the form of a mimeographed sheet under the title of 'Commercial Mineral Notes,' and sent to those on the mailing list of CALIFORNIA JOURNAL OF MINES AND GEOLOGY.

EMPLOYMENT SERVICE

Following the establishment of the Mining Division branch offices in 1919, a free technical employment service was offered as a mutual aid to mine operators and technical men for the general benefit of the mineral industry.

Briefly summarized, men desiring positions are registered, the cards containing an outline of the applicant's qualifications, position wanted, salary desired, etc., and as notices of 'positions open' are received, the names and addresses of all applicants deemed qualified are sent to the prospective employer for direct negotiations.

Telephone and telegraphic communications are also given immediate attention.

Technical men, or those qualified for supervisory positions, and vacancies of like nature only, are registered, as no attempt will be made to supply common mine and mill labor.

Registration cards for the use of both prospective employers and employees may be obtained upon request, and a cordial invitation is extended to the industry to make free use of the facilities afforded. Parties interested should communicate direct with our San Francisco office.

PUBLICATIONS OF THE DIVISION OF MINES

During the past sixty-two years, in carrying out the provisions of the organic act creating the former California State Mining Bureau, there have been published many reports, bulletins and maps which go to make up a library of detailed information on the mineral industry of the State, a large part of which could not be duplicated from any other source.

One feature that has added to the popularity of the publications is that many of them have been distributed without cost to the public, and even the more elaborate ones have been sold at a price which barely covers the cost of printing.

Owing to the fact that funds for the advancing of the work of this department have usually been limited, the reports and bulletins mentioned are printed in limited editions many of which are now entirely exhausted.

Copies of such publications are available for reference, however, in the offices of the Division of Mines, in the Ferry Building, San Francisco; State Building, Los Angeles; State Office Building, Sacramento; Redding; and Division of Oil and Gas at Santa Barbara, Santa Paula, Taft, Bakersfield, Coalinga. They may also be found in many public, private and technical libraries in California and other states and foreign countries.

A catalog of all publications from 1880 to 1917, giving a synopsis of their contents, is issued as Bulletin No. 77.

Publications in stock may be obtained postpaid by addressing the San Francisco, Los Angeles or Sacramento offices and enclosing the requisite amount.

Remittances of stamps in an amount not to exceed 26 cents, currency or coin will be accepted at sender's risk. Payment is preferred in the form of money orders.

Money orders should be made payable to the Division of Mines.

NOTE.—The Division of Mines frequently receives requests for some of the early Reports and Bulletins now out of print, and it will be appreciated if parties having such publications and wishing to dispose of them will advise this office.

Write for latest revised price list.

REPORTS

Asterisks (**) indicate the publication is out of print.

	Price (including postage and sales tax)
**First Annual Report of the State Mineralogist, 1880, 43 pp. Henry G. Hanks	----
**Second Annual Report of the State Mineralogist, 1882, 514 pp., 4 illustrations, 1 map. Henry G. Hanks	----
**Third Annual Report of the State Mineralogist, 1883, 111 pp., 21 illustrations. Henry G. Hanks	----
**Fourth Annual Report of the State Mineralogist, 1884, 410 pp., 7 illustrations. Henry G. Hanks	----
**Fifth Annual Report of the State Mineralogist, 1885, 234 pp., 15 illustrations, 1 geological map. Henry G. Hanks	----
Sixth Annual Report of the State Mineralogist, Part I, 1886, 145 pp., 3 illustrations, 1 map. Henry G. Hanks Price $0.75, sales tax $0.02	$0.77
Part II, 1887, 222 pp., 36 illustrations. William Irelan, Jr. Price $0.75, sales tax $0.02	.77
**Seventh Annual Report of the State Mineralogist, 1887, 315 pp. William Irelan, Jr.	----
**Eighth Annual Report of the State Mineralogist, 1888, 948 pp., 122 illustrations. William Irelan, Jr.	----
**Ninth Annual Report of the State Mineralogist, 1889, 352 pp., 57 illustrations, 2 maps. William Irelan, Jr.	----
**Tenth Annual Report of the State Mineralogist, 1890, 983 pp., 179 illustrations, 10 maps. William Irelan, Jr.	----
Eleventh Report (First Biennial) of the State Mineralogist, for the two years ending September 15, 1892, 612 pp., 73 illustrations, 4 maps. William Irelan, Jr. Price $1.50, sales tax $0.05	1.55
**Twelfth Report (Second Biennial) of the State Mineralogist, for the two years ending September 15, 1894, 541 pp., 101 illustrations, 5 maps. J. J. Crawford	----
**Thirteenth Report (Third Biennial) of the State Mineralogist, for the two years ending September 15, 1896, 726 pp., 93 illustrations, 1 map. J. J. Crawford	----
Chapters of the State Mineralogist's Report, XIV Biennial Period, 1913-1914, Fletcher Hamilton:	
**Mines and Mineral Resources, Amador, Calaveras and Tuolumne Counties, 172 pp., paper	----
Mines and Mineral Resources, Colusa, Glenn, Lake, Marin, Napa, Solano, Sonoma and Yolo Counties, 208 pp., paper Price $0.75, sales tax $0.02	.77
**Mines and Mineral Resources, Del Norte, Humboldt and Mendocino Counties, 59 pp., paper	----
**Mines and Mineral Resources, Fresno, Kern, Kings, Madera, Mariposa, Merced, San Joaquin and Stanislaus Counties, 220 pp., paper	----
**Mines and Mineral Resources of Imperial and San Diego Counties, 113 pp., paper	----
**Mines and Mineral Resources, Shasta, Siskiyou and Trinity Counties, 180 pp., paper	----
**Fourteenth Report of the State Mineralogist, for the Biennial Period 1913-1914, Fletcher Hamilton, 1915: A General Report on the Mines and Mineral Resources of Amador, Calaveras, Tuolumne, Colusa, Glenn, Lake, Marin, Napa, Solano, Sonoma, Yolo, Del Norte, Humboldt, Mendocino, Fresno, Kern, Kings, Madera, Mariposa, Merced, San Joaquin, Stanislaus, San Diego, Imperial, Shasta, Siskiyou and Trinity Counties, 974 pp., 275 illustrations, cloth	----
Chapters of the State Mineralogist's Report, XV Biennial Period, 1915-1916, Fletcher Hamilton:	
**Mines and Mineral Resources, Alpine, Inyo and Mono Counties, 176 pp., paper	----
Mines and Mineral Resources, Butte, Lassen, Modoc, Sutter and Tehama Counties, 91 pp., paper Price $0.75, sales tax $0.02	.77

REPORTS—Continued

Asterisks (**) indicate the publication is out of print.

	Price (including postage and sales tax)
Mines and Mineral Resources, El Dorado, Placer, Sacramento and Yuba Counties, 198 pp., paper Price $0.75, sales tax $0.02	$0.77
Mines and Mineral Resources, Monterey, San Benito, San Luis Obispo, Santa Barbara and Ventura Counties, 183 pp., paper Price $0.75, sales tax $0.02	.77
**Mines and Mineral Resources, Los Angeles, Orange and Riverside Counties, 136 pp., paper	----
**Mines and Mineral Resources, San Bernardino and Tulare Counties, 186 pp., paper	----
**Fifteenth Report of the State Mineralogist, for the Biennial Period 1915-1916, Fletcher Hamilton, 1917: A General Report on the Mines and Mineral Resources of Alpine, Inyo, Mono, Butte, Lassen, Modoc, Sutter, Tehama, Placer, Sacramento, Yuba, Los Angeles, Orange, Riverside, San Benito, San Luis Obispo, Santa Barbara, Ventura, San Bernardino and Tulare Counties, 990 pp., 413 illustrations, cloth	----
Chapters of the State Mineralogist's Report XVI, Biennial Period, 1917-1918, Fletcher Hamilton:	
Mines and Mineral Resources of Nevada County, 270 pp., paper Price $1.00, sales tax $0.03	1.03
Mines and Mineral Resources of Plumas County, 188 pp., paper Price $0.75, sales tax $0.02	.77
Mines and Mineral Resources of Sierra County, 144 pp., paper Price $0.75, sales tax $0.02	.77
Seventeenth Report of the State Mineralogist, 1920, 'Mining in California during 1920,' Fletcher Hamilton; 562 pp., 71 illustrations, cloth Price $2.50, sales tax $0.08	2.58
Eighteenth Report of the State Mineralogist, 1922, 'Mining in California,' Fletcher Hamilton. Chapters published monthly beginning with January, 1922:	
**January, **February, **March, **April, May, June, July, August, September, October, November, December, 1922 Price $0.40, sales tax $0.01	.41
Chapters of Nineteenth Report of the State Mineralogist, 'Mining in California,' Fletcher Hamilton and Lloyd L. Root. January, February, March, September, 1923 Price $0.40, sales tax $0.01	.41
Chapters of Twentieth Report of the State Mineralogist, 'Mining in California,' Lloyd L. Root. Published quarterly. January, April, July, October, 1924, per copy Price $0.40, sales tax $0.01	.41
Chapters of Twenty-first Report of the State Mineralogist, 'Mining in California,' Lloyd L. Root. Published quarterly:	
January, 1925, Mines and Mineral Resources of Sacramento, Monterey and Orange Counties Price $0.40, sales tax $0.01	.41
April, 1925, Mines and Mineral Resources of Calaveras, Merced, San Joaquin, Stanislaus and Ventura Counties Price $0.40, sales tax $0.01	.41
**July, 1925, Mines and Mineral Resources of Del Norte, Humboldt and San Diego Counties	----
**October, 1925, Mines and Mineral Resources of Siskiyou, San Luis Obispo and Santa Barbara Counties	----
Chapters of Twenty-second Report of the State Mineralogist, 'Mining in California,' Lloyd L. Root. Published quarterly:	
**January, 1926, Mines and Mineral Resources of Trinity and Santa Cruz Counties	----
April, 1926, Mines and Mineral Resources of Shasta, San Benito and Imperial Counties Price $0.40, sales tax $0.01	.41
July, 1926, Mines and Mineral Resources of Marin and Sonoma Counties Price $0.40, sales tax $0.01	.41
**October, 1926, Mines and Mineral Resources of El Dorado and Inyo Counties, also report on Minaret District, Madera County	----

REPORTS—Continued

Asterisks (**) indicate the publication is out of print.	Price (including postage and sales tax)
Chapters of Twenty-third Report of the State Mineralogist, 'Mining in California,' Lloyd L. Root. Published quarterly:	
January, 1927, Mines and Mineral Resources of Contra Costa County; Santa Catalina Island Price $0.40, sales tax $0.01	$0.41
April, 1927, Mines and Mineral Resources of Amador and Solano Counties Price $0.40, sales tax $0.01	.41
**July, 1927, Mines and Mineral Resources of Placer and Los Angeles Counties	--
October, 1927, Mines and Mineral Resources of Mono County Price $0.40, sales tax $0.01	.41
Chapters of Twenty-fourth Report of the State Mineralogist, 'Mining in California,' Lloyd L. Root. Published quarterly:	
January, 1928, Mines and Mineral Resources of Tuolumne County Price $0.40, sales tax $0.01	.41
April, 1928, Mines and Mineral Resources of Mariposa County Price $0.40, sales tax $0.01	.41
**July, 1928, Mines and Mineral Resources of Butte and Tehama Counties	----
October, 1928, Mines and Mineral Resources of Plumas and Madera Counties Price $0.40, sales tax $0.01	.41
Chapters of Twenty-fifth Report of the State Mineralogist, 'Mining in California,' Walter W. Bradley. Published quarterly:	
**January, 1929, Mines and Mineral Resources of Lassen, Modoc and Kern Counties; also on Special Placer Machines	----
**April, 1929, Mines and Mineral Resources of Sierra, Napa, San Francisco and San Mateo Counties	----
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March 1, 1941.

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9—11057 6-42 2M

STATE OF CALIFORNIA
DEPARTMENT OF NATURAL RESOURCES
KENNETH I. FULTON, Director

DIVISION OF MINES
FERRY BUILDING, SAN FRANCISCO

WALTER W. BRADLEY State Mineralogist

Vol. 38 April, 1942 No. 2

CALIFORNIA JOURNAL
OF
MINES AND GEOLOGY

QUARTERLY CHAPTER
OF
STATE MINERALOGIST'S REPORT XXXVIII

STATE DIVISION OF MINES
FERRY BUILDING, SAN FRANCISCO
CALIFORNIA

14672

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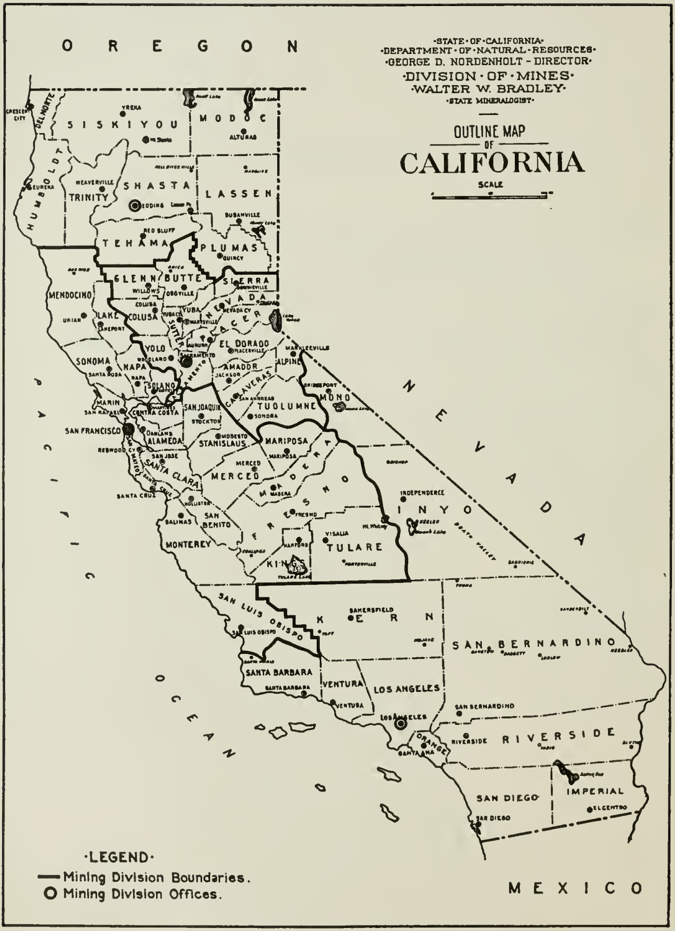
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SISKIYOU
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SAN BERNARDINO
RIVERSIDE
ORANGE
SANTA ANA
SAN DIEGO
IMPERIAL
EL CENTRO
·LEGEND·
Mining Division Boundaries.
O Mining Division Offices.

PREFACE

The Division of Mines (formerly State Mining Bureau) is maintained for the purpose of assisting in all possible ways in the development of California's mineral resources.

As one means of offering tangible service to the mining public, the State Mineralogist for many years has issued an annual or a biennial report reviewing in detail the mines and mineral deposits of the various counties.

As a progressive step in advancing the interests of the mineral industry, and as permitting earlier distribution to the public, publication of the Annual Report of the State Mineralogist in the form of monthly chapters was begun in January, 1922, and continued until March, 1923. Owing to a lack of funds for printing this was changed to a quarterly publication, beginning in September, 1923. For the same reason, beginning with the January, 1924, issue, it became necessary to charge a subscription price. This covers approximately the cost of printing.

Pages are numbered consecutively throughout the year and an index to the complete report is included annually in the closing number.

Beginning with the 1930 issues, the activities and progress of the Geologic Branch are recorded also in these quarterly chapters. The important part that geology plays in the economic development of our mineral resources is further recognized in the change of title from *Mining in California* to CALIFORNIA JOURNAL OF MINES AND GEOLOGY, beginning with the January, 1933, chapter.

While current activities of all descriptions are covered in these chapters, the practice of issuing from time to time technical reports on special subjects will be continued as well. A list of such reports now available is appended hereto, and the names of new bulletins will be added in the future as they are completed.

The chapters are subject to revision, correction and improvement. Constructive suggestions from the mining public will be gladly received, and are invited.

The one aim of the Division of Mines is to increase its usefulness and to stimulate the intelligent development of the wonderful, latent resources of the State of California.

Types of Reports

In general the reports presented in these chapters are grouped into three classes:

1. Mines and mineral resources of a given county or area (describing kind, character, distribution and extent of development).

2. Specific economic and industrial mineral products (listing and describing the resources over the entire state of a given mineral substance, e.g., feldspar).

3. Geological reports on specific areas (recording results and conclusions with maps, derived from field studies; and tied in with economic possibilities and developments).

REPORTS OF DISTRICT MINING ENGINEERS

In 1919–1920 the Mining Bureau was organized into four main geographical divisions, with the field work delegated to a mining engineer in each district, working out from field offices that were established in Redding, Auburn, San Francisco and Los Angeles, respectively. This move brought the office into closer personal contact with operators, and it has many advantages over former methods of conducting field work, including lower traveling-expense bills for the Bureau's engineers. In 1923 the Redding and Auburn field offices were consolidated and moved to Sacramento.

The Redding office was reestablished in 1928, and the boundaries of each district adjusted. The counties now included in each of the four divisions and the locations of the branch offices are shown on the accompanying outline map of the State. (Frontispiece.)

Reports of mining activities and development in each district, prepared by the District Engineer, will continue to appear under the proper field division heading.

LOS ANGELES FIELD DISTRICT

MINERAL RESOURCES OF IMPERIAL COUNTY

By R. J. Sampson and W. B. Tucker, Mining Engineers

OUTLINE OF REPORT

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INTRODUCTION

Imperial County formed part of San Diego County from the organization of the latter in 1850 to August, 1907, when it was created into a separate county by vote of the supervisors of San Diego County, under an act of the Legislature, giving them that power. The principal industries of Imperial County are agriculture, stock raising and dairying. Its mineral resources are varied and extensive and the rapid and continued growth of the towns of Imperial Valley and the manufacturing industries of the Pacific Coast have led to the development of deposits of structural and industrial materials throughout the county.

DESCRIPTION

Imperial County is bounded on the east by the State of Arizona, on the north by Riverside County, on the west by San Diego County and on the south by Mexico. Its area is 4089 square miles, with a population of 60,894 (1930 census). The county is served by two railroads, the Southern Pacific and the San Diego & Arizona. The transcontinental line of the Southern Pacific Railroad enters the county on the north near Durmid on the eastern shore of the Salton Sea and runs southeasterly through the county to Yuma, Arizona. From the main trunk line, a branch from Niland runs through Imperial Valley to El Centro and Calexico and continues on into Mexico, connecting Mexicali with Yuma. The San Diego & Arizona Railroad enters the county from the west, connecting San Diego with Imperial Valley at El Centro. Two main highways afford easy access to the county from the north. The highway (U. S. 80) between San Diego and El Centro forms part of the coast route from Los Angeles to Imperial Valley, Yuma and Phoenix. The other route known as U. S. 99, from Los Angeles to Imperial Valley, is over the Valley Boulevard by way of Beaumont and Banning to Brawley and El Centro. The Blythe-Glamis route to Yuma and Imperial Valley is one of the main desert roads which enters the county from the northeast at Palo Verde and runs southwest to Glamis, then north to Niland and connects with the highway from Niland to Mecca. Recently a highway from Julian has been built into the county from the west and connects with Highway U. S. 99 at Kane Springs. Water for irrigation of Imperial Valley is now being served by the Imperial main canal which water is taken out of the Colorado River, a few miles below Yuma, Arizona, and runs through Mexico and back into the United States, near Calexico. The All-American Canal now under construction is entirely in the United States. The All-American Canal diverts from the Colorado River at a point about 5 miles above the Laguna Dam, of the Yuma irrigation project, in Sec. 9, T. 15 S., R. 24 E., S. B. M. The Imperial diversion dam is of the slat-and-buttress type, with a total length of 3485 ft., inclusive of nonoverflow sections, headworks, gate structures, sluiceway and overflow spillway. The overflow section is 1200 ft. long, with a maximum height of 43 ft. The maximum height of the dam is 85 ft. and the maximum base thickness is 75 ft. The Colorado River at the site of the diversion dam and headworks, carries large quantities of suspended silt. To decrease the amount of silt entering the All-American Canal, a desilting plant has been constructed immediately down stream from the headworks of the canal. The desilting plant consists of three basins, each of which is 500 ft. by 800 ft. in plan and 12.5 ft. deep, with an influent channel through the center. The silt deposited in the basins is removed continuously and mechanically by means of 72 motor-driven, rotating mechanisms, each 125 ft. in diameter and sluiced into the river below the dam. The scrapers are controlled in groups of 24 from a main control house at the west end of the dam. The main canal to Imperial Valley is 80 miles long and the branch to Coachella Valley, 130 miles. From the diversion dam to the Siphon Drop on the Reservation division of the Yuma irrigation project, where 2000 second-feet are diverted for this project, the capacity of the canal is 15,000 second-feet; 13,000 second-feet from Siphon Drop to Pilot Knob; and 10,000 second-feet westward from Pilot Knob for the Imperial and Coachella valleys. The Coachella Canal will have an initial capacity of 2500 second-feet as it leaves the main canal.

The Imperial Dam, Siphon Drop section of the All-American Canal, is 232 ft. wide at the water surface, 21 ft. deep, 160 ft. bottom width and will carry an amount of water equal to 70 per cent of the average flow of the Colorado River at Boulder Dam.

LOCATION

The route of the canal (see Map) follows the river closely to Laguna Dam, then parallels the present Yuma main canal to the Siphon Drop. From the Siphon Drop to Pilot Knob, the canal follows the foothills. Beyond Pilot Knob, at three different points and for a total distance of 14.8 miles, the canal is located near to and parallel with the international boundary. For 10½ miles, the canal line passes through the sand hills. The deepest cut in the sand hill area is over 100 ft. and the dune sand is about 80 ft. in depth. From the sand hills, the canal runs west across the East Mesa to the present East High Line Canal of the Imperial district distribution system and then through the extreme southern portion of Imperial Valley where it crosses 17 principal ditches and passes around the town of Calexico before it reaches its terminus, the present West Side Main Canal. At this point, the Canal has a capacity sufficient to supply lands under the West Side Canal, also, additional lands on the West Side Mesa and furnish 155 second-feet for the City of San Diego.

COACHELLA CANAL

About 15 miles west of Pilot Knob, the Coachella Branch Canal takes out of the All-American Canal and runs in a northwesterly direction across the East Mesa. It crosses the Southern Pacific Railroad near Iris Station, passes east of the Salton Sea and Coachella Valley, in Riverside County, to a point near the towns of Indio and Coachella, where it again crosses the Southern Pacific Railroad and runs southwesterly across the valley and the south to the Riverside-Imperial county line. The capacity at the head will be 2500 second-feet.

The Imperial Irrigation District has a complete canal distribution system in Imperial Valley, with about 450,000 acres in cultivation. In Coachella Valley about 16,000 acres are now under cultivation, being supplied by pumping from wells. In Coachella Valley, there are about 150,000 acres of irrigable lands. There are about 1,000,000 acres of irrigable lands which can be irrigated under this All-American and Coachella Branch canal system.

POWER DEVELOPMENT

There are opportunities for the development of power by the Imperial Irrigation District and the Coachella Valley County Water District at five drops in the Main Canal and two drops on the Coachella Branch Canal. The Irrigation District has sole right to any power developed at Pilot Knob with the 3000 second-feet of water in excess of the irrigation requirements for which capacity is being provided to that point. Benefits from any additional power developed at Pilot Knob or any power developed at the various drops in the canal below that point, will be divided between the districts in proportion to the amount each is to contribute to the cost of the works from and including Imperial Dam down to the site of each respective power development. Power possibilities on the canal from Imperial Dam down to and including Siphon Drop are reserved to the United States.

GEOLOGY

The most useful references on the geology of the region are Blake's original description of the Salton Basin,[1] Mendenhall's papers on Coachella Valley and Carrizo Creek,[2] Fairbank's report,[3] and U. S. Geol. Survey Water Supply Paper No. 497, 'The Salton Sea Region, California,' by John S. Brown. In the following notes on the geology of Imperial County, excerpts are taken from the last-named paper:

According to most geologists who have worked in this region, the oldest rocks are probably of pre-Cambrian age. The pre-Cambrian rocks occur mainly in the desert mountains in the region between the Salton Basin and the Colorado River. They are commonly flanked by Tertiary or later sediments about the mountain borders and in large areas they are covered or intruded by Tertiary volcanic rocks. The rocks that can most certainly be referred to as the oldest series consist of granite and granitic gneiss. In this series probably belong the granite and schist that compose most of the Cargo Muchacho Range and the granite, slate and schist that form the basements of the Picacho Hills and the eastern part of the Chocolate Mountains. On the western border of the desert in Carrizo Mountain and on the top of Fish Mountain in the Carrizo Creek region, are beds of marble and some schist and sandstone which have been referred by Mendenhall and Fairbanks to the Paleozoic, with suggestion that they may be Carboniferous. Marble, schist and gneiss of undetermined age in the Santa Rosa Mountains may belong to the same series of rocks as the Carrizo Mountain District.

TERTIARY SEDIMENTARY DEPOSITS

Sedimentary beds, believed to be of Tertiary age, occupy extensive areas along the southwest and northeast sides of the Salton Basin and presumably underlie practically the entire basin. The largest and best-known exposures southwest of Salton Sea are in Carrizo Creek Valley, around Yuha Well, south of the Santa Rosa Mountains and northeast of Superstition Mountain and Borego Mountain and on the north side of Fish Mountain. The Tertiary beds consist of soft, poorly consolidated conglomerates, sand and clay containing in places, a large amount of gypsum and some other saline materials. Part of the Tertiary beds in the region are marine and part terrestrial. Marine beds cover large areas in the Carrizo Creek region where they contain abundant marine fauna and are represented around Carrizo Mountain and north of Fish Mountain by chemical deposits such as gypsum and strontianite which were evidently deposited in water.

TERTIARY AND QUATERNARY VOLCANIC ROCKS

The volcanic rocks of this area are probably mostly Tertiary; some of them are Quaternary. They occur as flows interbedded with sedimentary beds in the Carrizo region, around Superstition Mountain and in Iris Pass. The lavas are most prominent in the Chocolate and Palo Verde mountains. The Palo Verde Mountains are entirely volcanic, being chiefly a mass of andesitic or rhyolitic flows. The Chocolate Mountains, from one end to the other, exhibit a great mixture of andesitic and rhyolitic flows with possibly syenite and trachyte in the west end.

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[1] Blake, W. P., Pacific Railroad Reports, Vol. V, 1853.

[2] Mendenhall, W. C., Ground waters of the Indio Region, Calif., with a sketch of the Colorado Desert; U. S. Geol. Surv., Water Supply Paper No. 225, 1909.

[3] Fairbanks, Harold W., Geol. of San Diego, Orange and San Bernardino Counties; State Mineralogist's Rept. XI, pp. 76-120, 1892.

The only volcanic material of unquestionably Quaternary age in this region is found in the vicinity of the mud volcanoes southeast of Salton Sea where three or four small buttes of black obsidian protrude through the Quaternary silt.

QUATERNARY DEPOSITS

The Quaternary deposits immediately underlie nearly all of the lowlands and have the largest areal extent of all the rock formations. They underlie the larger part of the Salton Basin and practically all of the Colorado River Valley. The valley fill consists of sand, gravel and clay washed down from the hills and mountains.

MINERAL RESOURCES

The last general report on the mines and mineral resources of Imperial County appeared in Report XXII of the State Mineralogist, published in April, 1926. In the January, 1940, issue of California Journal of Mines and Geology, there is a brief report on the active gold mines operating in the Ogilby District at which time there was considerable mining activity in the Cargo Muchacho and Tumco mining districts. During 1939, Imperial County produced 13 different substances, having a total value of $822,271, of which 67,328 lb. of copper was produced valued at $7002.00 and the gold production was $687,995.00, the greatest production recorded by the county. It ranks in that year as the thirty-second county in the State in mineral production. Imperial County contains commercial deposits of clay, copper, cyanite, gold, gems, gypsum, lead, manganese, marble, mineral paint, pumice, salt, silver, sodium sulphate, strontium, sulphur and talc.

The attached table gives the complete recorded output and the value of the mineral production from 1907 to and including 1941.

METALS

COPPER

The occurrence of copper ores in the county is limited to the Picacho and Paymaster districts and in the Fish Mountains. In the former district stains of copper are widely disseminated through a considerable area three miles southeast of Picacho. A number of claims have been located in this area which are held by annual assessment work.

In the Paymaster District, the chief mineralization is in Sec. 23 and 26, T. 12 S., R. 20 E., S. B. M., 16 miles east of Glamis. The oxides and carbonates of copper occur along shear zones in schists and along fractures in the monzonite. The occurrence of copper sulphides was noted, finely disseminated in the monzonite. A number of claims have been located and considerable surface prospecting has been done along the highly mineralized zones. On the west slope of Fish Mountains, copper occurs as copper oxides and carbonates.

MINERAL PRODUCTION OF IMPERIAL COUNTY,[1] 1907-1941

Year	Brick		Gold, value	Silver, value	Miscellaneous stone, value	Miscellaneous and unapportioned		
	M	Value				Amount	Value	Substance
1907	1,000	$10,000						
1908	2,225	22,250	$5,848	$123		375 lbs.	$51	Copper.
1909	2,000	20,000	59,705	524				
1910	1,680	10,078	[2]87,341	[2]237				
1911	1,200	7,000	[2]97,855	[2]189				
1912	3,250	20,000			$10,000			
1913	5,500	44,000	31,700	94	12,000	750 cu.ft.	7,260	Marble.
1914	4,900	29,400	210,428	8,961		13,081 lbs.	1,730	Copper.
1915	2,958	17,916	14,369	42	40,095	65 lbs.	11	Copper.
							5,000	Other minerals.
1916	[3]		23,338	155	34,834		47,006	Brick, copper, lead, pumice, strontium.
1917	and tile	19,260	919	5	65,660	1,907 tons	38,140	Manganese.
							5,416	Copper, potash, pumice.
1918	and tile	11,670	247	1,248	34,787	1,241 tons	46,900	Manganese.
							14,840	Copper, lead, pumice.
1919	[3]			8,607	63,900		67,936	Brick, lead, pumice, salt.
1920	[3]			2,183	127,412	624 tons	16,500	Pumice.
							23,787	Other minerals.
1921	654	6,363	537	920	171,173		3,825	Other minerals.
1922			350	18,024	154,560		15,805	Brick, gypsum, lead, marble, pumice.
1923					101,833		162,900	Brick, gold, gypsum, pumice, silver, soda (salt cake).
1924			258	1	78,032		61,617	Brick, gems (dumortierite), gypsum, pumice.
1925	[3]		[3]	[3]	148,942		182,023	Brick, kyanite, gypsum and pumice.
1926	[3]		238	19	312,130		154,927	Brick, kyanite, gypsum, lead and pumice.
1927	[3]		257	3	129,658		221,059	Brick, copper, kyanite, gypsum and pumice.
1928	[3]		25	1	98,790		142,862	Brick, copper, kyanite, feldspar, gypsum, pumice, silica.
1929			1,030	16	230,199		278,587	Bentonite, copper, kyanite, feldspar, mica, pumice, silica.
1930			148		218,686		149,189	Gypsum, pumice, kyanite.
1931			649	1	429,782		97,594	Gypsum, mica, pumice, kyanite.
1932			16,212	149	171,694		63,672	Clay (pottery), gypsum, mica, pumice, kyanite.
1933			6,293	76	86,962		73,527	Carbon dioxide, clay, gypsum, mica, kyanite.
1934			9,973	71	48,066		50,370	Carbon dioxide, kyanite, copper, gypsum, pumice, salt.
1935			59,406	2,981	20,695		41,053	Carbon dioxide, gypsum, mica, pumice, salt, kyanite.
1936			41,965	573	143,530		70,873	Carbon dioxide, copper, gypsum, lead, mica (schist), pumice, salt.
1937			298,095	2,542	197,981	118,138 lbs.	14,295	Copper.
						8,210 lbs.	484	Lead.
							154,004	Carbon dioxide, clay, gypsum, iceland spar, mica (schist), pumice, salt, kyanite.
1938			448,490	2,800	60,871	70,000 lbs.	6,860	Copper.
							87,206	Carbon dioxide, kyanite, gypsum, iceland spar, mica (schist), salt.
1939			687,995	6,076	75,440	67,328 lbs.	7,002	Copper.
							75,440	Carbon dioxide, kyanite, gypsum, iceland spar, lead, limestone, manganese ore, salt.

MINERAL PRODUCTION OF IMPERIAL COUNTY,[1] 1907-1941—Continued

Year	Brick		Gold, value	Silver, value	Miscellaneous stone, value	Miscellaneous and unapportioned		
	M	Value				Amount	Value	Substance
1940			252,665	1,865	64,553	11,201 lbs.	1,266	Copper.
							140,831	Carbon dioxide, kyanite, gypsum, iceland spar, limestone, magnesite, salt, strontium, sulphur.
1941			86,765	362	65,203		426,478	Calcium chloride, carbon dioxide, copper, gypsum, iceland spar, manganese ore, mica (schist), salt, kyanite, soda (salt cake), strontium, sulphur.
Total values		[3]$217,937	[3]$2,443,101	[3]$58,848	$3,397,468		$2,958,336	

[1] Imperial County was created August, 1907, from a part of San Diego County.
[2] Includes production of San Diego County.
[3] See under 'Unapportioned.'

The only production of copper was from American Girl Mine in the Cargo Muchacho District, from flotation concentrates shipped to smelters which contained 3% copper. The production for 1939 amounted to 67,328 lb. of copper.

MINES AND PROSPECTS

Campbell Group of Claims are located on the west slope of Fish Mountains, 15 miles northwest of Coyote Wells. The ore occurs as oxides and carbonates of copper. Development consists of surface trenches and shallow shafts. Owner is George Campbell, Seely, Calif. Idle.

Bibl.: State Mineralogist's Report XXII, p. 252.

Cave Man Group of Claims comprises 4 claims located in Sec. 26, T. 12 S., R. 20 E., S. B. M., in the Paymaster Mining District, 16 miles east of Glamis; owner, E. B. Dykes, Riverside, Calif.

The formation is schist, quartzite and monzonite. The ore occurs along contact of schist and quartzite. In the vicinity of this contact for a distance of 20 ft., the rock is mineralized with malachite and azurite. The strike of the contact is N. 30° W.

The principal development work is on the Cave Man Claim and consists of open cuts and a short tunnel 40 ft. in length. Idle.

Bibl.: State Mineralogist's Report XXII, p. 252.

Picacho Copper Deposit. The property comprises 160 acres situated in Sec. 1, T. 14 S., R. 22 E., S. B. M., in the Picacho Mining District, located 2 miles southeast of Picacho and about 3 miles east of Picacho Peak.

The schist in this area strikes NW. and dips 50° SW. Surface stains of copper are widely disseminated throughout this belt of schist. The principal mineralization appears for a mile in length and about one-quarter of a mile in width. The mineralization is along shear zones in the schist that strike NW. The schist is heavily stained with malachite.

Development work on the deposit consists of five shafts 50 ft. to 75 ft. deep and a number of trenches and open cuts exposing some low-grade ore. On the north end of the deposit are a number of siliceous outcrops that are mineralized with chalcopyrite. Idle.

Bibl.: State Mineralogist's Report XXII, p. 252.

Volunteer Group of Claims comprises 8 claims located in Sec. 23 and 26, T. 12 S., R. 20 E., S. B. M., 16 miles east of Glamis, in the Paymaster Mining District; owner, P. J. Kane, Brawley, Calif.

The chief mineralization on these claims occurs along fractures in the monzonite which strike N. and dip 80° E. The fractures are mineralized with malachite and azurite, and in one prospect hole, the monzonite shows copper sulphides disseminated through the rock. On the south slope of a small hill several shafts have been sunk to depths of 10 ft. The main working shaft has been sunk to a depth of 70 ft. on a fracture in the monzonite which strikes N. and dips 70° E. The mineralized fracture is 6 ft. in width. Samples taken from these workings are reported to assay from 2% to 10% copper, with $5.00 in gold and silver.

In 1926, the owner installed a small leaching plant on the property. Only assessment work is being done on the claims. Idle.

Bibl.: State Mineralogist's Report XXII, p. 253.

GOLD

Gold is widely scattered over the desert region of the county and has probably been mined to some extent in every mountain range. It occurs as placer gold; in veins of quartz in granitic rocks and in mineralized zones in schist. The gold deposits that have been productive in the past occur in the southeastern corner of the county, in the mountain ranges between the line of the Southern Pacific Railroad and the Colorado River. The principal producing districts are located in the Cargo Muchacho Mountains which trend northwest and in the Picacho Mountains which also have a northwest trend along the Colorado River. Scattered occurrences of gold are also found in the Chocolate Mountains which trend northwest into Riverside County.

The Cargo Muchacho Mountains are made up of metamorphic gneiss and schist, cut by pegmatite dikes and lie three to four miles northeast of the line of the Southern Pacific Railroad, their southeasterly extremity being nine miles from Yuma. In the northern section of the mountains is the Tumco Mining District and in the southern section is the Cargo Muchacho Mining District. Hedges Mountain has an altitude of 2225 ft., while Cargo Muchacho Peak has an elevation of 2130 ft. Many auriferous veins have been found along the ridges of the Cargo Muchacho Mountains and in all the gulches and washes leading from them. Placer gold has been abundant.

The Picacho Mountains, of which the chief summit is El Picacho, attains a height of 1945 ft. The mountains are made up of volcanic lavas, tuffs and conglomerates. The volcanics are underlain by metamorphic schists and gneisses which contain the chief gold deposits and are probably the same age as those of the Cargo Muchacho Mountains. Mining has been carried on in the Picacho District almost continuously since 1857 to 1910, and in 1938 to 1939 there was a revival of placer and lode mining but only a small production was made. At the present time, outside of assessment work, there is no active mining under way.

The Chocolate Mountains are made up of pre-Cambrian, metamorphic gneiss and mica and hornblende schists, cut by pegmatite dikes. Southeast of Midway Well, the schists and gneiss are underlain by volcanic lavas, tuffs and conglomerates. The principal activity in mining in Chocolate Mountains, has been north and east of Glamis, due to the discovery of a rich gold deposit known as the Mary Lode by Vander Pool and Murphy, 9 miles northeast of Glamis. There was considerable activity in the Mesquite District caused by the drilling and development of the dry placer deposits by the Desert Gold & Aluminum Corp., of Seattle, Wash. In the Paymaster District, the Paymaster silver mine was under development during 1937 to 1940. Due to the fact that manganese has been designated as one of the strategic minerals, there has been considerable activity in the location of claims on manganese deposits southeast of Midway Well in the Paymaster Mining District. The Tolbard manganese deposits from which considerable ore was shipped in 1917-1918 have been relocated by the Black Hill Manganese Corp., of Beverly Hills, Calif. The property is under development and ore mined is being stock-piled for shipment.

In the Cargo Muchacho Mountains, mining has been done on a large scale at various times since 1879. In 1937, there was a renewal of mining activity in the district which extended until the early part of 1940. During this period the following mines were under continuous operation: American Girl, Blossom, Cargo Muchacho, Golden Queen, Madre and Padre, and Sovereign Mines. However, with the depletion of the orebodies in the above-mentioned mines, there is now only a small amount of activity in the Cargo Muchacho and Tumco mining districts.

MINES AND PROSPECTS

American Girl Mine. The property comprises 16 patented mining claims totaling 320 acres, situated in Sec. 17, T. 15 S., R. 21 E., S. B. M., 5 miles northeast of Ogilby, a station on the Southern Pacific Railroad; elevation 750 ft.; owner, O'Brien Mines Co., Inc., J. J. O'Brien, president; A. T. Balmforth, secretary, Grosse Point Farms, Mich. The property was operated from September, 1936 until August, 1939 when operations were suspended due to low grade tenor of ore encountered below the 740-ft. level.

The country rock is of igneous origin, the syenites and granites of the range giving way to gneiss and schist. This formation has been faulted and metamorphosed and greatly broken up and altered, probably through the agency of a large porphyry dike 200 ft. thick which cuts through the hills in a northeast direction to the west of the property. Between the porphyry dike and the range to the south is a mineralized zone which is 500 ft. in width. Three parallel veins occur in schist, strike E.-W. and dip 35° S. The outcrops can be traced on the surface for a distance of two miles. The veins have a thickness of 20 ft. to 50 ft. The ore in these veins is a soft, fine-grain schist, with an intermingling of quartz. The vein quartz is mineralized with pyrite and chalcopyrite. The pyrite and chalcopyrite carry values in gold.

The principal development work is on what is known as the Brown vein. The American Girl shaft has been sunk on an inclination of 35° in the footwall of the Brown vein to a depth of 730 ft. The main working shaft, known as Tybo shaft, is located 750 ft. west of the American Girl shaft and is sunk on the Brown vein to a depth of 850 ft. on an inclination of 35°. The two shafts are connected at 400, 500, 600 and 740-ft. levels. The White vein occurs on the north side of the Brown vein and was worked from the American Girl shaft on 100 and 150-ft. levels and stoped for a distance of 110 ft. east of American Girl shaft. The Blue vein occurs in the arroyo north of Brown vein but very little work has been done on this vein. The vein material is schist, with a small content of quartz containing 4% pyrite.

In the latter part of 1936, a flotation plant was installed on the property with a capacity of 140 tons per 24 hr. Shortly afterwards the capacity was increased to 165 tons. From January 1, 1937, to August, 1939, when operations were suspended, there was mined and milled from the property approximately 150,000 tons of ore with an average value of $6.00 per ton in gold. From 165 tons of crude ore milled, 10 tons of flotation concentrate was produced which carried $150.00 per ton in gold, with a 3% to 5% copper content. The recovery made was 88%, with a loss of 60¢ to $1.00 per ton in tailings. All mine and mill equipment has been removed from the property. Idle.

Bibl.: State Mineralogist's Reports XIII, p. 331; XIV, pp. 728-729; XXII, p. 255; XXXVI, pp. 15-16.

Big Bear & Little Bear Mines comprise 2 claims situated in the Cargo Muchacho Mining District, in Sec. 30, T. 15 S., R. 21 E., S. B. M., one mile southwest of Padre Mine and 4 miles east of Ogilby, a station on the Southern Pacific Railroad; owners, Balch, Contaras and Bennett, El Centro, Calif.

The vein occurs on contact of granite and schist, with granite as the footwall and a schist hanging wall. The strike is E.-W., dip 50° S. Width is 8 in. to 15 in.

Development consists of shaft 100 ft. in depth, sunk on an inclination of 35°. On the 40-ft. level, there is a drift on the vein 40 ft. in length. Idle.

Big Tree Mine comprises one claim situated in the Mesquite Mining District, in Sec. 21, T. 13 S., R. 19 E., S. B. M., 8 miles northeast of Glamis, a station on the Southern Pacific Railroad; owners, John A. Anderson and James T. Bowers, Glamis, Calif.

The claim adjoins the Desert Gold & Aluminum Corporation's property on the west. The vein occurs in schist, is 16 ft. in width; strike NW.-SE. and dips 45° SW. A pocket of high-grade wire gold extracted is reported to be valued at $300. Developed by 2 shafts about 100 ft. apart to depths of 18 ft. Idle.

Blossom Mine. The property comprises 2 patented claims known as the Drifted Snow No. 4, Drifted Snow No. 5; owner, Vitrefrax Corp., 5050 Pacific Ave., Vernon, Calif. During 1939, the mine was under lease to Thomas Woodruff, of Los Angeles. The property is situated in the Cargo Muchacho Mining District, in Sec. 19, T. 15 S., R. 21 E., S. B. M., 4 miles east of Ogilby, a station on the Southern

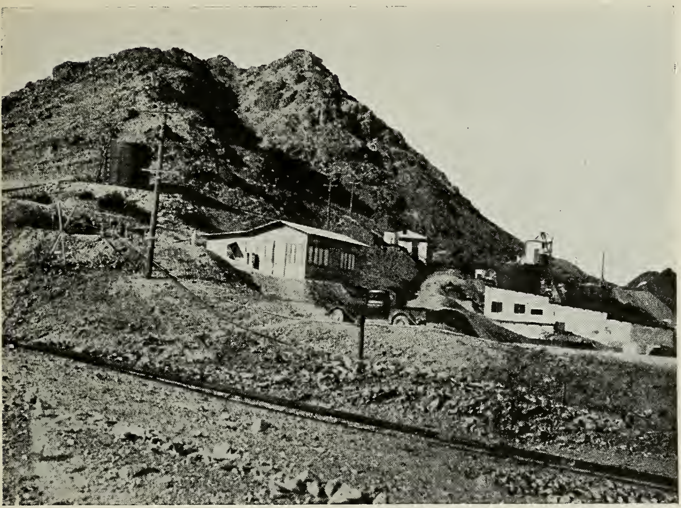

FIG. 1. Tybo Shaft and 160-Ton Flotation Plant, American Girl Mine, Ogilby, Imperial Co.

Pacific Railroad; elevation 400 ft. Two parallel veins occur in gneissoid granite, strike N. 20° W. and dip 50° W. Width of veins varies from one to 4 ft.

Developed by 3 shafts. The Blossom shaft was sunk on the vein to a depth of 280 ft. It is now caved. About 400 ft. south of this shaft, the Valencia was sunk on the Blossom vein to a depth of 240 ft. On the 140-ft. level, there is a drift south on the vein 100 ft. and drift north 20 ft. to east-west fault. At this point, a crosscut was driven east 23 ft. which cut the faulted segment of the vein. The vein has an average width of 4 ft. which was drifted on to the south 40 ft., then a winze was sunk on the vein to a depth of 50 ft. The vein quartz is mineralized with free gold, associated with pyrite and chalcopyrite. Valencia No. 2 shaft is located east of these workings and has been sunk on a parallel vein to a depth of 70 ft. The operators shipped 150 tons of ore which had an average value of $15.00 per ton in gold. Idle.

Bibl.: State Mineralogist's Reports XII, p. 238; XIII, p. 332; XIV, p. 729; XXII, p. 255; XXXVI, p. 17.

Butterfly Group of Mines comprises 7 claims situated in the Cargo Muchacho Mining District, in Sec. 17, T. 15 S., R. 21 E., S. B. M., 4 miles east of Ogilby, a station on the Southern Pacific Railroad; elevation 800 ft.; owner, S. C. Samson, Ogilby, Calif. The claims are located east of the American Girl Mine.

The vein occurs in schist, strikes NW. and dips 40° SE.; width 2 ft. to 4 ft. Developed by an incline shaft sunk on the vein to a depth

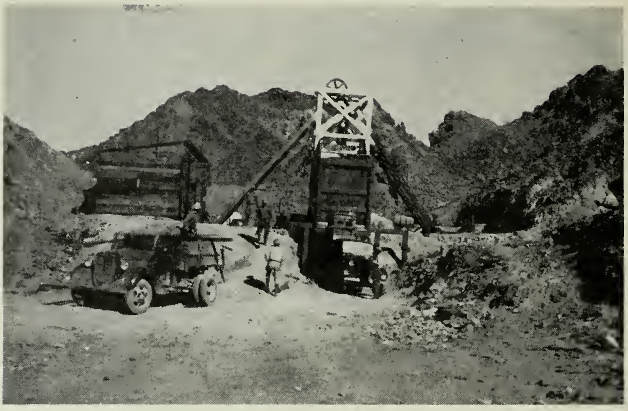

FIG. 2. Head Frame—Cargo Muchacho Shaft, Cargo Muchacho Mine, Ogilby, Imperial Co.

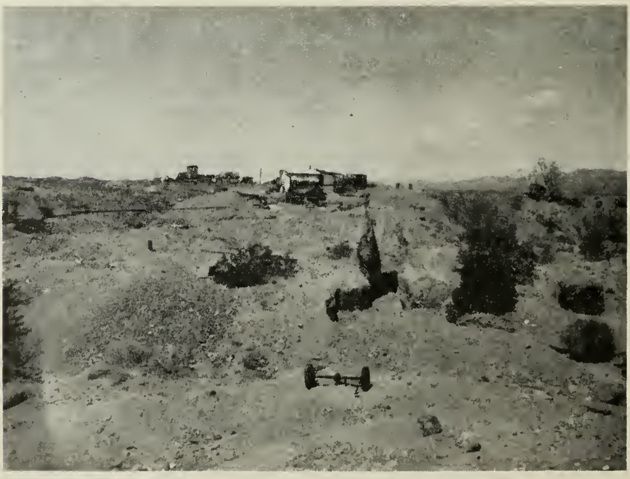

FIG. 3. Mesquite Gold Placers, Desert Gold & Aluminum Corp., Mesquite Diggings, Imperial Co.

of 325 ft. The vein has been developed on 100, 200, and 300-ft. levels. Idle.

Bibl.: State Mineralogist's Report XXII, p. 255.

Cargo Muchacho Mine. The property comprises 2 patented claims, Cargo Muchacho and First Extension, totaling 40.8 acres, in Sec. 20 and 29, T. 15 S., R. 21 E., S. B. M., in the Cargo Muchacho Mining District, 4 miles east of Ogilby, a station on the Southern Pacific Railroad; elevation 800 ft.; owner, Rafetz Corp., 5225 Wilshire Blvd., Los Angeles. In 1937 and 1938, the property was under lease to the Holmes & Nicholson Mining & Milling Co., Kenneth Holmes, president and manager, Yuma, Arizona.

The vein occurs in gneissoid granite; strike N.-S., dip 45° to 60° E. The vein varies in width from 2 ft. to 8 ft. The main working shaft is 550 ft. in depth. The south shaft has a depth of 200 ft. Approximately 200 ft. north of the main shaft, a fault which strikes E.-W., dip vertical, displaces the vein and no ore was developed north of this fault. Development was confined to the 350 and 400-ft. levels. The ore mined from these levels is reported to have an average value of $20.00 per ton in gold. About 500 tons of old tailings from the old mill on the property was shipped to the company's mill at Winterhaven. The average value of the tailings treated was reported to be $5.00 per ton in gold. Idle.

Bibl.: State Mineralogist's Reports VI, p. 81; XI, p. 385; XII, p. 239; XIII, p. 334; XIV, p. 729; XXII, p. 255.

Coffey Mine. It comprises 6 claims situated on the west slope of the Cargo Muchacho Mountains, in the Tumco Mining District, 5 miles north of Ogilby; elevation 800 ft.; owner, Edward Coffey, Ogilby, Calif.

A quartz vein occurs in gneissoid granite; strike N. 40° E., dip 35° SE. Width of vein varies from 8 in. to 2 ft. Vein quartz is mineralized with hematite and copper oxides.

Development consists of a shaft sunk on the vein to a depth of 150 ft. On the other claims are some shallow shafts and open cuts. Equipment consists of Ingersoll-Rand tugger hoist; 300-cu. ft. Ingersoll-Rand compressor; ore bin having a capacity of 25 tons. Idle.

Bibl.: State Mineralogist's Report XXXVI, p. 17.

Desert Gold & Aluminum Corp., S. C. Hedrick, president; Alton Peterson, secretary, Seattle, Wash. This company owns 800 acres in placer claims; also, has a lease on the Copenhagen Group comprising 80 acres situated in the Mesquite Mining District, in T. 11 N., R. 18 E., 9 miles east of Glamis, a station on the Southern Pacific Railroad; elevation 800 to 900 ft. In January, 1941, the property was leased to Reese Production Co., Mathew M. Reese, president and general manager, 945 Thirteenth North, Seattle, Wash. Mine address is Glamis, Calif.

The former operators prospected the company's ground with an aeroplane drill. Some 52 holes from 16 ft. to 50 ft. deep were put down. These holes are said to have determined an area of gold-bearing gravel 2 miles long in a north-south direction and one-half mile wide and from 16 ft. to 50 ft. deep. The average values indicated are reported as $1.07 per cu. yd.

On the Gordeau Claims comprising 6 placer claims adjoining the company's property on the west, three trenches have been made in the gulches by steam shovel. One of these is 1500 ft. long; the other two, 500 ft. in length. The width in each is approximately 25 ft., with depths of 8 ft. to 12 ft.

The present operator has erected a mill at a well some 5 miles south of these workings. The material is loaded in 5-ton trucks with power shovel and hauled to the mill where it is dumped from ramp to bin to 10-in. by 20-in. jaw crusher; then to inclined conveyor to cylindrical bin to 4½-ft. by 14-ft. tube mill, over short amalgamation plates; riffled launder to cone classifier to 4-ft. by 12-ft. amalgamation plates and corduroy table to elevator and then to 80-ft. sluice box to tails. Capacity of the plant is 100 tons per day. A recovery of $2.00 per ton in gold is reported.

Mr. Reese states his object is to demonstrate that there is here available a large tonnage of material which can be profitably treated if handled on a large scale. Seventeen men are employed.

> Bibl.: State Mineralogist's Reports XIV, p. 731; XXII, pp. 258-259; XXXVI, pp. 17-18.

Desert King Mine. It comprises 4 claims located in Sec. 12, T. 15 S., R. 20 E., S. B. M., in Hedges Mining District, in the Cargo Muchacho Mountains, 5 miles north of Ogilby, a station on the Southern Pacific Railroad; owners, C. S. Walker and B. F. Harrison, Ogilby, Calif.

The vein strikes N. 60° W. and dips 55° SW. It has a width of 2 ft. to 4 ft. The vein occurs in a micaceous quartz schist which is cut in all directions by pegmatite dikes that vary in width from a few inches to several feet. The ore is a quartzose schist, stained with copper and is said to average from $8.00 to $15.00 per ton in gold. The development on the vein consists of a shaft sunk on the vein to a depth of 150 ft. On the 75-ft. level, there is a drift 100 ft. east and 125 ft. west. On the 150-ft. level, there is a drift 50 ft. east and 50 ft. west. A crosscut tunnel has been driven north 75 ft., connecting with the shaft on the 75-ft. level. About 300 ft. west of these workings, at a lower elevation, a crosscut tunnel has been driven N. 60° E., 300 ft. At 100 ft. from the portal, cut a small ore shoot which has been stoped to the surface.

During 1938, a small amalgamation and flotation plant was installed on the property but after a short period of operation, work was suspended. Idle.

> Bibl.: State Mineralogist's Report XXII, pp. 255-256.

Duncan Mine (Trio). It comprises 8 claims located 1½ miles northeast of Laguna Dam, in the Yuma Irrigation District of the All-American Canal, in Sec. 23, T. 15 S., R. 24 E., 16 miles northeast of Yuma; elevation 151 ft.

The Duncan vein strikes N. 40° W. and dips 35° SW.; width 3 ft. to 10 ft.; on contact of schist and granite, with granite on the footwall and schist as the hanging wall. Development consists of a shaft sunk on the vein to a depth of 240 ft. The ore body developed was 85 ft. in length, with an average width of 4 ft. and stoped from 165-ft. level to the surface. Ore is reported to have had an average value of $11.00 per ton in gold. The property was operated in 1898.

West of the Duncan Mine is the Trio Group. In 1933 the Trio Mining Co. of Los Angeles, Sam Mosher, president, acquired both groups of claims and the Trio Group was under development from 1933 to 1935.

The vein on the Trio strikes NE.-SW. and dips 50° NW.; width 3 ft.; in schist. Development consists of incline shaft 60 ft. deep and a vertical shaft sunk in granite, the hanging wall of the vein, to a depth of 75 ft.

The property was acquired by Imperial Irrigation District when the All-American Canal was under construction.

El Lucerne Mine. It comprises 5 claims situated in Picacho Mining District, about 4 miles from the Colorado River and 17 miles northeast of Yuma; elevation 450 ft.; owner, Philip Hess, Yuma, Arizona. Idle.

Bibl.: State Mineralogist's Report XXII, p. 256.

Gold Basin Mine. It comprises 4 claims located in Sec. 3, T. 12 S., R. 20 E., S. B. M., 18 miles northeast of Ogilby, a station on the Southern Pacific Railroad and 1½ miles east of the Glamis-Palo Verde road, in the Chocolate Mountains; owner, C. A. Gibson, Brawley, Calif.

A series of parallel veins of quartz 12 in. to 18 in. in width occurs in quartz-diorite. The veins strike NE.-SW. and dip 60° to 70° to the SE. A number of shafts have been sunk on the different veins to depths of 20 ft. to 100 ft. Idle.

Bibl.: State Mineralogist's Report XXII, p. 257.

Gold Delta Placer Mines comprise five 160-acre placer claims situated in the Mesquite Mining District, adjoining the property of the Desert Gold & Aluminum Corp. on the south, in Sec. 20, T. 13 S., R. 19 E., S. B. M., 9 miles east of Glamis, a station on the Southern Pacific Railroad; elevation 700 ft.; owners, Gold Deltas Corp., C. R. Zappone, president; Clarence E. Weaver, secretary, 1001 Subway Terminal Bldg., Los Angeles.

The gravels lie along washes of present water courses from the Chocolate Mountains which drain into the bed of a dry lake against the sand hills, 10 miles to the south. The placer gravels on this group of claims have a depth of 300 ft. to bed rock. The general course of the channel carrying values is reported to be north and south. Shafts and open cuts along the channel indicate a length of 2 miles, with a width of one-half of a mile.

Development consists of a shaft sunk through unconsolidated gravel to bed rock to a depth of 300 ft. They are sinking a new shaft to the north of this shaft, present depth of which is 60 ft. Pay gravel extracted from bottom of 300 ft. is reported to be 6 ft. in thickness, with values in gold reported to vary from 50 cents to $2.00 per cu. yd. Idle.

Golden Queen Mine (Tumco Mines). The Golden Queen group of mines includes the Golden Crown and Golden Cross mines located on the western slope of the Cargo Muchacho Mountains, in the Tumco Mining District, in Sec. 1 and 12, T. 15 S., R. 20 E., and in Sec. 6 and 7, T. 15 S., R. 21 E., S. B. M.; elevation 650 ft.; owners, C. S. Walker and B. H. Harrison, Ogilby, Calif. From 1937 to 1941 this group of mines was under lease to the Sovereign Mining & Development Co., Courtney F. Baylor, president, 15 State St., Boston, Mass.; G. J. Harbauer, manager; W. M. Ballinger, superintendent. This company confined its operations to the Golden Cross and Golden Crown mines, retimbering the workings, also, doing some diamond drilling and it is reported a large tonnage of low grade was indicated in lower levels of these properties. Operations were suspended in June, 1942.

Thomas L. Woodruff, former manager of the Sovereign Mining & Development Co., secured a lease on the Golden Queen Mine and operated the property from 1940 to 1941 during which period he mined 3400 tons of ore above the 600-ft. level. The ore shipped is reported to have had an average value of $25.00 per ton in gold. It was shipped to American Smelting & Refining Company's smelter at Hayden, Arizona, and Magma Copper Company's smelter at Superior, Arizona.

The Golden Queen and Golden Crown veins occur in a micaceous quartz schist cut by pegmatite dikes. On strike and dip the veins conform to the schistosity of the enclosing rocks; strike N. 35° E.; dip 30° S. Widths vary from 6 ft. to 25 ft. The Golden Queen Mine is developed by a shaft sunk 1100 ft. on 30° inclination. Levels were driven at 300, 450, 500, 600, 700 and 800-ft. horizons, aggregating some 5000 ft. of underground workings. There is also a 300-ft. vertical shaft about 250 ft. south of incline shaft. These shafts are connected by drift and crosscut on the 450-ft. level of the incline shaft.

The Golden Crown shaft, now caved, was sunk 1100 ft. on about 35°. Levels were driven at approximately 100-ft. intervals. The Golden Cross shaft was sunk 1200 ft. on 37° inclination. Levels were driven at 100-ft. intervals. During 1941 the shaft was cleaned out and retimbered. On the 200-ft. level, the hanging wall crosscut was opened for a distance of 380 ft. without going through the caved ground or reaching the hanging wall. Similar work was also done on the 300-ft. level. Then it was decided to reopen the shaft to the 800-ft. level. The 500-ft. level was reached in April, 1941.

The underground workings of the Golden Queen, Golden Crown and Golden Cross are said to aggregate more than 8 miles. Total production from these properties is reported to be in excess of $2,000,000.00. Three men are employed diamond drilling on the Golden Crown Mine.

Bibl.: State Mineralogist's Reports XII, p. 240; XIII, p. 337; XIV, pp. 726-728; XXII, pp. 257-258; XXXVI, p. 18.

La Colorado Mine. It comprises 12 claims situated on the north slope of the Cargo Muchacho Mountains, in Sec. 25 and 26, T. 14 S., R. 20 E., S. B. M., 7 miles north of Ogilby, a station on the Southern Pacific Railroad; elevation 1400 ft.; owner, J. H. Mueller, c/o A. Blaisdell, Dool Bldg., Calexico, Calif.; under lease to George Wyman, Glendale, Calif. The property was discovered in 1914 and relocated in May, 1932 by Jose Villa, Yuma, Arizona.

Two parallel veins occur in quartzose, gneissoid granite and the mineralization occurs along certain bedding planes. The veins strike N. 60° W. and dip 25° SW. Widths of veins vary from 6 ft. to 35 ft. Development consists of incline shaft 200 ft. in depth, tunnel 200 ft. in length and a vertical shaft 70 ft. deep, with 200 ft. of drifts on the 65-ft. level.

Equipment consists of 6-h.p. gas engine hoist and 150 cu. ft. Ingersoll-Rand compressor. Idle.

Bibl.: State Mineralogist's Report XXXVI, pp. 18, 19.

Madre and Padre Mines. The property comprises 2 patented claims and 8 claims held by location, situated on the west slope of the Cargo Muchacho Mountains, in the Cargo Muchacho Mining District, in Sec. 19 and 20, T. 15 S., R. 20 E., S. B. M., 4 miles east of Ogilby; elevation 700 ft.; owner, Holmes & Nicholson Mining & Milling Co., Kenneth Holmes, president and manager, Yuma, Arizona.

The Madre-Padre veins occur in gneissoid granite and schists, with granite on footwall and schist on the hanging wall. Veins strike N. 30° W., dip 15° W. Width of vein varies from 6 ft. to 18 ft. In the Madre No. 2 workings, on the footwall of the vein, is a mud dike. The material is probably an andesite tuff. Considerable faulting on the vein occurs between Madre No. 1 and Madre No. 2 workings. A series of reverse faults displaces the vein in places from 20 ft. to 30 ft. Two orebodies have been developed known as Madre No. 1 and Madre No. 2. Madre No. 1 orebody is 200 ft. in length with an average width of 6 ft. It is reported to have an average value of $15.00 per ton in gold. Madre No. 2 orebody is 400 ft. in length with an average width of 6 ft. The average value is reported to be $14.00 per ton in gold. Madre No. 1

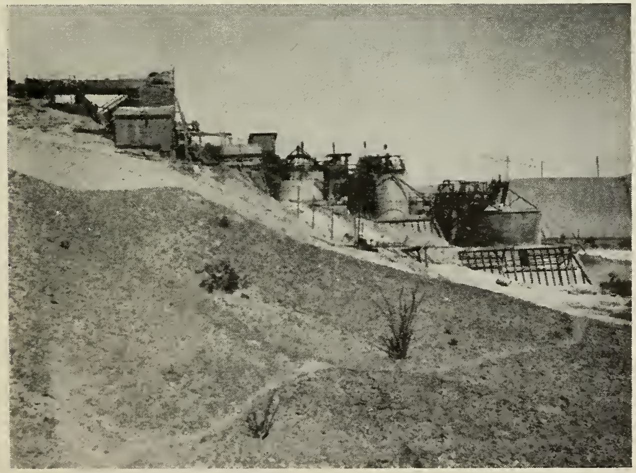

FIG. 4. 70-ton Cyanide Plant, Holmes & Nicholson Mining & Milling Co., Winterhaven, Imperial Co.

shaft is sunk on the vein to a depth of 250 ft. Madre No. 2 shaft is 300 ft. north of Madre No. 1 shaft and is sunk on the vein to a depth of 325 ft. Padre No. 1 shaft is 500 ft. north of Madre No. 2, and is sunk on the vein to a depth of 300 ft. Workings are caved.

Production from property is 75 tons per day. Mine equipment consists of two 50-h.p., single drum gasoline-driven hoists; 2 Ingersoll-Rand compressors: one 320-cu. ft. capacity, the other 220-cu. ft. Ore mined is hauled by trucks to the company's mill at Winterhaven, a distance of 12 miles.

The cyanide plant has a capacity of 70 tons per 24 hr. Mine run of ore is dumped over grizzly into bin with a capacity of 100 tons; from coarse-ore bin by belt conveyor to No. 37 Kennedy gyratory crusher where it is crushed to 1-in. size; then by 18-in. belt conveyor to Symonds vibrating screen; screened to ½-in. size; oversize from screen returned to gyratory crusher; ½-in. product to fine ore bin, with a capacity of 75 tons; belt feeder from fine ore bin to 5 ft. by 6 ft. Allis Chalmers ball mill, in closed circuit with 6 ft. by 25 ft. Duplex Dorr classifier. Ball mill and classifier are driven by 100-h.p. motor. Ore is ground to 80% on 200 mesh; pulp to all slime cyanide process, with Merrill-Crowe precipitation process. Average grade of ore milled is reported to be $15.00 per ton in gold. Recovery is reported to be 95%, with a loss of 50 cents to $1.00 per ton in tailings. Total horsepower required to operate cyanide plant is 240. Power is purchased from Nevada-California Power Co. Forty men are employed.

Bibl.: State Mineralogist's Reports XII, p. 242; XIII, p. 343; XXII, p. 259; XXXVI, pp. 19-20.

Mary Lode Mine. It comprises 6 claims situated on the south slope of Squaw Peak in the Chocolate Mountains, in Sec. 14 and 15, T. 12 S., R. 18 E., S. B. M., 10 miles northeast of Glamis; elevation 900 to 1000 ft.; owners, James Murphy and W. R. Van Derpool, El Centro, Calif.

A discovery of high-grade gold ore was made on these claims in April, 1939. The quartz vein occurs in quartz-diorite; strikes N. 70° E. and dips 35° N. It varies in width from 4 ft. to 6 ft. It has been traced on the surface for a distance of 660 ft. The gold, all free, is associated with hematite, largely on fracture faces. In this iron oxide, the gold is easily visible and some fine specimens have been found. The ore contains about one-half as much silver by weight as it does gold. The silver occurs as argentite.

Development consists of 2 shafts each sunk to 50 ft. on 35° inclination. On the 50-ft. level of the westernmost shaft, a drift has been driven east 80 ft. The new shaft is 120 ft. east of the original shaft. At the 25-ft. level, they are driving a drift to connect with 50-ft. level of the west shaft.

Shipments of ore aggregating 200 tons have been made from the property and 80 tons of ore were milled, recovering $12,000. The recovery was $150.00 per ton, with $50.00 per ton in the tailings.

Equipment consists of Gardner-Denver 105-cu. ft. capacity, portable compressor and gasoline hoist. Three men are employed.

Mendeville Group of Claims. It comprises 2 claims situated one mile east of the Picacho Basin Mine, in the Picacho Mining District, in Sec. 13, T. 14 S., R. 22 E., S. B. M., 20 miles north of Yuma, Arizona; elevation 650 ft.; owner, J. Mendeville, Yuma, Arizona.

The vein occurs in a silicified schist, is 50 ft. in width, strikes N. and dips 60° W. It is developed by shafts and a crosscut tunnel. Idle.

Bibl.: State Mineralogist's Report XXII, p. 258.

Mesquite Lode Mine. It comprises 9 claims situated on the south slope of the Chocolate Mountains, in the Mesquite Mining District, in Sec. 27, T. 12 S., R. 19 E., S. B. M., 10 miles east of Glamis; elevation 1500 ft.; owners, Robert Patterson, Clyde Patterson and Staley Johnson, Holtville, Calif.

The vein occurs in schist, strikes N. 20° W. and dips 38° SW.; width 2 ft. to 4 ft. On Mesquite Lode Claim No. 2, a tunnel has been driven on the vein a distance of 50 ft.; also open cuts made along outcrop of vein for a distance of 250 ft. The ore mined is reported to have an average value of $20.00 per ton. Two men are employed on development.

Mesquite Placers (See Desert Gold & Aluminum Corp.).

Ogilby Group of Mines. It comprises 7 claims located in the Cargo Muchacho Mountains, in the Cargo Muchacho Mining District, in Sec. 17, T. 15 S., R. 21 E., S. B. M., 4 miles northeast of Ogilby; elevation 750 ft.; owner, S. C. Samson, Ogilby, Calif.

The vein is in a quartzose schist which is mineralized with gold, associated with pyrite. The vein strikes NW.-SE. and dips 35° SW. Development consists of 6 shafts, the deepest being 500 ft. Idle.

Bibl.: State Mineralogist's Report XXII, p. 259.

Pasadena and Occidental Group of Mines comprises 2 patented claims in the Pasadena Group and 7 patented claims in the Occidental Group. The Pasadena Group is in Sec. 16 and the Occidental Group is in Sec. 20, 21, T. 15 S., R. 21 E., S. B. M., in the Cargo Muchacho Mountains, 4 miles north of Ogilby, a station on the Southern Pacific Railroad; elevation 700 ft.; owner, Henry J. Mundenk, Los Angeles.

On the Pasadena Group there are two parallel veins in gneissoid granite; strike N. 20° E., dip 40° E. Widths vary from 12 in. to 2 ft. Development consists of a shaft 100 ft. in depth and 3 tunnels. No. 2 tunnel is 200 ft., No. 3 tunnel is 100 ft. and No. 4 tunnel is 500 ft.

On the Occidental Group there is a series of parallel veins in gneissoid granite; strike N. 15° W., dip 35° W. Widths vary from 12 in. to 2 ft. Development consists of shafts, open cuts and tunnels. Idle.

Bibl.: State Mineralogist's Reports XI, p. 386; XII, p. 242; XIII, p. 343; XIV, p. 729; XXII, p. 260.

Peg Leg Mine. It is situated on the east slope of the Chocolate Mountains, in Sec. 31, T. 10 S., R. 17 E., S. B. M., 15 miles east of Niland; elevation 900 ft.

The vein occurs in granite, strikes N. 30° W.; dip vertical; width 2 ft. Development consists of 2 shafts, one 150 ft. deep, the other 75 ft. in depth. Idle.

Bibl.: State Mineralogist's Report XXII, p. 260.

Picacho Basin Mine (Placer). The basin consists of low, rolling hills covered in part by washed gravel and detritus from the neighboring hills. These superficial deposits are gold-bearing and have been washed by Mexicans for years and recently, by dry washing machines. The gravels have been worked along the arroyo between the Picacho Lode Mine and the old village at Picacho. It is reported that the gold-bearing gravels have an average value of 35 cents per cu. yd. These gravel deposits are 25 miles north of Yuma. Idle.

Bibl.: State Mineralogist's Report XXII, p. 260; Bull. 92, p. 156.

Picacho Gold Mines (Picacho Basin). The property comprises 36 claims located in Sec. 3 and 10, T. 14 S., R. 22 E., S. B. M., about 5 miles south of the Colorado River and 20 miles north of Yuma, Arizona; elevation 580 ft.; owner Picacho Gold Mining Co., E. L. Jones, president; E. H. Page, secretary, 1045 Michigan Ave., Pasadena, Calif.

Three parallel lenses of ore occur in schist. These orebodies are known as Dulcinca, Apache and San George. The general strike of the lenses is N. 45° W., with a dip of 45° SW. The Apache and San George orebodies are in a rough, mountainous country, while the Dulcinca is located on fairly level ground. The Dulcinca ore shoot was 250 ft. in length by 150 ft. in width. It was developed and worked by two shafts to a depth of 250 ft. and 450 ft. The ore was mined from a glory hole which was 250 ft. in length by 160 ft. in width. The Diablo shaft is located 750 ft. southwest of the glory hole. The shaft was sunk on an inclination of 50° to a depth of 450 ft., with two compartments. Levels were driven at 50-ft. intervals. Most of the stoping was northwest of the shaft. A large tonnage of ore was milled and said to average $3.00 per ton in gold.

The property was worked from 1904 to September, 1910, by the Picacho Basin Mining Co. The production during this period of operations was about $2,000,000.00. In January, 1937, the property was acquired by the Picacho Gold Mining Co. who carried on an intensive drilling and sampling of the property with a Worthington vacuum drill. During 1937, they drilled 47 holes, with a total footage of 8154, the deepest hole being 100 ft.; average depth of holes being 67 ft. From 1938 to 1939, they drilled 449 holes, with a total footage of 42,382, the deepest hole being 150 ft.; the average depth of hole being 94 ft. The cost of drilling was 30 cents per foot. It is reported the average value of samples taken from the holes drilled was $2.50 per ton in gold.

The latter part of 1939, the property was under option to Nipissing Mining Co., Ltd., Quebec, Canada. This company planned to install a 500-ton cyanide plant but was forced to surrender its option when war was declared between England and Germany. Idle.

Bibl.: State Mineralogist's Reports XII, pp. 237-243; XIII, pp. 331-346; XIV, pp. 729-730; XXII, pp. 260-261; XXXVI, p. 20.

Potholes (placer). These dry placers are located 10 miles northeast of Yuma, Ariz. and several miles west of Laguna Dam; elevation 150 ft. The gold-bearing gravels of this region were extensively worked in the early days by Indians and Mexicans and are now worked out. The Potholes placers have produced considerable gold. The production is reported to have been $2,000,000.

Bibl.: State Mineralogist's Reports XII, p. 242; XIII, p. 344; XXII, p. 261; Bull. 92, p. 155.

Senator Mine. This mine comprises one patented claim located in Sec. 8, T. 15 S., R. 24 E., S. B. M., 13 miles northeast of Yuma and 3 miles north of Laguna Dam; elevation 250 ft.; owner W. W. Williams, San Bernardino, Calif.

A quartz vein 8 ft. wide occurs in schist. It strikes NW.-SE. and dips 70° SW. Development consists of an incline shaft sunk on the vein to a depth of 300 ft. Drifts have been driven on the vein on the 100, 180 and 270-ft. levels. Idle.

Bibl.: State Mineralogist's Report XXII, p. 261.

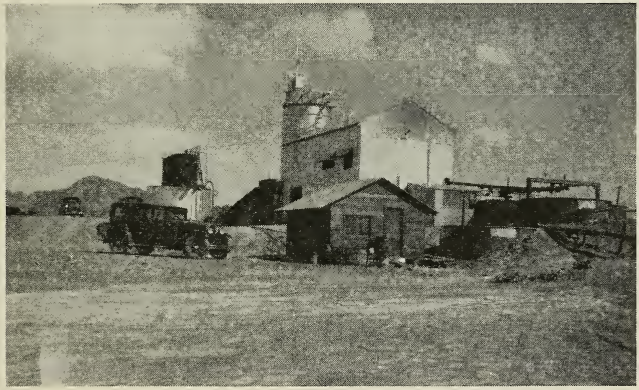

FIG. 5. 30-ton Cyanide Plant, Sovereign Mining & Development Co., Ogilby, Imperial Co.

Sovereign Mines comprise 12 claims situated in the Cargo Muchacho Mountains, in the Tumco Mining District, in Sec. 1 and 12, T. 15 S., R. 20 E. and in Sec. 6 and 7, T. 15 S., R. 21 E., S. B. M. and adjoins the Golden Crown on the east. The property is 4½ miles northeast of Ogilby, a station on the Southern Pacific Railroad; elevation 700 ft.; owner, Ben Harrison, Ogilby, Calif.; under lease and bond to Sovereign Mining & Development Co., Courtney Baylor, president, 15 State St., Boston, Mass.; G. M. Colvocoresses, consulting engineer, Phoenix, Ariz.; W. M. Ballanger, superintendent.

The vein occurs in a quartzose schist; strike N. 40° E., dip 25° SE. Its width varies from 4 ft. to 8 ft. The mineralization parallels the schistosity of the country rock. The vein quartz is mineralized with free gold, pyrite and chalcopyrite. Values ranged from $6.00 to $15.00 per ton in gold.

Development: Gold Bug or West Shaft was sunk to a depth of 150 ft. on a 30° inclination. On the 80-ft. level, there is a drift east

100 ft. and 60 ft. west, with a 30-ft. winze about 30 ft. east of shaft. The east shaft on Golden Eagle Claim is about 1500 ft. east of West Shaft. This shaft was sunk 450 ft. on a 25° inclination. On the 112-ft. level there is a drift southwest 400 ft. to a fault. At 60 ft. west of shaft, there is a stope 60 ft. long, 40 ft. high and 6 ft. wide.; drift east from shaft 25 ft. At the collar of this shaft, a tunnel has been driven southwest 300 ft. At 20 to 40 ft. below the surface, this ground has been stoped at intervals to the surface. The width of the vein was 4 ft. to 6 ft. This shoot was also developed from 200 and 300-ft. levels, the total production being 5500 tons which averaged $10.00 per ton. Ore was hauled from mine, a distance of 2½ miles southwest of Tumco to mill with a capacity of 30 tons per day and consisted of the following: 15-ton bin, belt feeder to 9-in. by 15-in. jaw crusher; elevator to circular steel bin, 100-ton capacity; belt conveyor to 10-ft. Lane mill, hydraulic classifier to 2-ft. by 12-ft. amalgamation plates to sump; from sump by 2-in. centrifugal pump to Dorco diaphragm pump to six 12-ft. by 5-ft. steel tanks where it is leached by cyanide solution, to zinc boxes. Mill was driven by 2-cylinder, 75-h.p. diesel engine.

Production from this property is reported to be $50,000.00. Idle.

Bibl.: State Mineralogist's Report XXXVI, pp. 20-21.

Telluride Mine (Golden Eagle). The property comprises 7 claims situated on the west slope of the Cargo Muchacho Mountains, in the Tumco Mining District, 7 miles north of Ogilby; elevation 800 ft.; owner, Telluride Gold Mining Co., A. J. Griffin, president; Rosco Ruff, secretary; R. N. Griffin, manager, P. O. Box 21, Yuma, Ariz.

Quartz vein occurs in gneissoid granite; strike NE.-SW., dip 15° NW. Width is 2 ft. to 4 ft. Development consists of two shafts, one vertical 50 ft. in depth and an incline shaft 136 ft. deep. On the 136-ft. level, a crosscut is driven north to intersect vein developed in vertical shaft.

Equipment consists of 6-h.p. gas-driven hoist and Gardner-Denver compressor driven by 15-h.p. Fairbanks-Morse compressor. Four men are employed.

Bibl.: State Mineralogist's Report XXXVI, p. 21.

IRON

Deposits of magnetite occur in the Chocolate Mountains, northeast of Amos, a station on the Southern Pacific Railroad.

Bibl.: State Mineralogist's Report XXII, p. 262.

LEAD AND SILVER

Lead-silver ores occur in the county in the Paymaster District on the eastern slope of the Chocolate Mountains, 17 miles northeast of Glamis, a station on the Southern Pacific Railroad. Lead carbonate and galena also occur in the Picacho District. The most productive mine was the Paymaster which was worked extensively from 1867 to 1880. Since the latter date, the property has been worked off and on by the owners and was under lease to William Green and associates, of Los Angeles, during 1938-1939 and several small shipments of ore were made to the United States Smelting Co., Salt Lake City, Utah.

Homestake Mine comprises 3 claims located one mile northeast of the Paymaster Mine and 2 miles west of Midway Well, in the Paymaster Mining District; elevation 750 ft.; owners, Vanya Laughlin and V. Bloomer, Brawley, Calif. Idle.

Bibl.: State Mineralogist's Report XXII, p. 262.

Mayflower Mine comprises 6 claims located in Sec. 11, T. 14 S., R. 22 E., S. B. M., 5 miles east of Picacho; owner, W. H. Trenchard, San Diego, Calif. Idle.

Bibl.: State Mineralogist's Report XXII, p. 262.

Paymaster Mine comprises 12 claims situated on the eastern slope of the Chocolate Mountains, in the Paymaster Mining District, in Sec. 19 and 30, T. 11 S., R. 20 E. and in Sec. 24 and 25, T. 11 S., R. 19 E., S. B. M., 25 miles by road northeast of Glamis and 3 miles west of Midway Well; elevation 800 ft.; owners, L. W. Jackson, Harold Jackson, Pasadena, Calif., and M. E. Stark, Beverly Hills, Calif.

The Paymaster vein strikes NW.-SE. and dips 60° to 70° NW. Width of vein varies from 15 ft. to 30 ft. The hanging wall of the vein is diorite, with granite as the footwall. Three ore shoots were developed along the vein which outcrop for a distance of 4000 ft. The ore shoots are known as Paymaster, President and Hazel. The Paymaster shaft was sunk to a depth of 385 ft. on a 70° incline, and ore stoped from 200-ft. level to the surface for a distance of 250 ft. in length. Width of ore mined was from 8 ft. to 15 ft. Two veins were worked known as Footwall and Hanging Wall. Levels were driven every 100 ft., with crosscuts run to the Footwall vein on each level. On the 300-ft. level, a winze was sunk to a depth of 85 ft. northeast of the shaft. About 1500 ft. east of the Paymaster workings is the President shaft and underground workings. The shaft was sunk on the footwall side of the vein to a depth of 452 ft. Drifts were driven on the vein on the following levels: 150, 200, 250, 300, 350 and 400-ft. The ore shoot was 250 ft. in length and 15 ft. to 35 ft. between walls. The footwall section of the vein was stoped from the 200-ft. level to the surface, while the hanging wall section of the vein was worked on the 300 and 400-ft. levels. The principal stopes are east of the shaft. The vein worked had a maximum width of 35 ft. The ore mined was silver chloride associated with lead carbonate and galena. Estimated tonnage of ore in the President Mine workings is about 80,000 tons, with an assay value of 8.2 oz. in silver; .015 oz. in gold; and 3.5% lead. Estimated tonnage between 100 and 400-ft. levels, is 35,000 tons, with an assay value of 12.09 oz. in silver; .01 oz. in gold; and 2.9% lead.

About 1800 ft. east of the President workings are the Hazel workings. Two shafts have been sunk on the vein to depths of 50 ft. and 100 ft. The vein exposed in these workings is 15 ft. wide. The ore is lead carbonate and galena, with values in silver. The ore mined is reported to assay 10% lead, with 6 oz. in silver. A new shaft has been sunk to a depth of 92 ft. between the Hazel and President shafts, developing a new ore shoot. This shaft is located 600 ft. west of the Hazel shaft and about 1100 ft. east of the President shaft. The vein strikes NE.-SW. and dips 70° NW. Width is 15 ft., with calcite filling between diorite and granite. On the footwall, there is 4 ft. of ore developed, reported to assay 10 oz. in silver; 10% lead; and .06 oz. in gold. The ore is lead carbonate and galena. Selected ore shipped ran 36% lead, with 40 oz. in silver. At the 45-ft. level a crosscut has been driven 15 ft. to the hanging wall of the vein. The owners of the property also own 40 acres of patented land located in Sec. 15, T. 11 S., R. 20 E., S. B. M., on which is located a well and pumping plant.

Equipment consists of 6-h.p. gas hoist, 9 in. by 8 in. C. P. compressor, 12-h.p. hoist. Idle.

Bibl.: State Mineralogist's Reports XIV, pp. 732-733; XXII, pp. 262-264.

Silver King Mine comprises 2 claims located in the Chocolate Mountains, 14 miles northeast of Glamis, in Sec. 23, T. 12 S., R. 19 E., S. B. M.; elevation 900 ft.; owners Charles Kurton, Glamis, Calif.; Robert D. Gunn, Royal D. Glick, Colton, Calif.

An aplite dike strikes No. 10° W. and dips 60° W.; width 15 ft. to 25 ft. The dike occurs in a gneissoid granite and is mineralized with gold, galena and copper oxides. The galena occurs in irregular bunches along fractures in the aplite dike. Some samples taken from the vein assayed 5 oz. in gold, 20% to 30% lead.

Development consists of shaft sunk on the footwall side of the aplite dike to a depth of 20 ft. Two men are employed on development.

MANGANESE

Commercial deposits of manganese occur in the Chocolate Mountains, east of Midway Well and in the Palo Verde Mountains, south and west of Palo Verde.

The most productive area has been in the Paymaster District, east of Midway. During 1917 and 1918, 3148 tons of ore was mined and shipped from Imperial County, value at $85,040. The largest production was from the Tolbard Manganese Mines, now operated by the Whedon Manganese Mines, Inc.

Chocolate Drop Manganese Mines comprise 4 claims situated in T. 9 S., R. 20 E., S. B. M., 6 miles south of Wileys Well, near the boundary line of Imperial and Riverside counties and 30 miles southwest of Blythe; owner, E. O. Tetzleff, Banning, Calif.; under lease to Mine Development Co., H. S. West, president, 610 South Broadway, Los Angeles; J. I. Moore, manager, San Bernardino, Calif.

The veins of manganese occur in an andesitic conglomerate and coarse layers of orange-colored sandstone. The general dip of the conglomerate is 10° to the northeast. The manganese occurs as psilomelane, occupying definite fissure veins. These veins are in the conglomerate. The veins strike N. 25° W. and dip west. Other veins cutting the conglomerate southwest of shaft, strike N.-S., N. 25° W. and N. 15° E., respectively, and have vertical dips. The contact of the conglomerate upon the underlying lava is exposed about one-half of a mile southwest of shaft. Just west of the contact, a vein of psilomelane, with N.-S. strike, cuts the lava with a vertical dip.

Development consists of shallow shafts and trenches. Assays of sorted ore are as follows:

Mn.	45.2%
Insol.	2.0%
BaO	13.8%
CaO	nil
Fe	2.2%
Available O	8.4%

In 1917, three hundred tons of ore was shipped from the property reported to average 46% Mn, with 2% SiO_2 and 2.2% Fe. Present operators shipped 40 tons of ore; average 43% Mn. Six men are employed on development work.

Desert Bloom Group of Manganese Claims. It comprises 4 claims situated on the east slope of the Palo Verde Mountains, in T. 9 S., R. 20 E., S. B. M., 6 miles southwest of Palo Verde; owners, Henry L. Jackson, Brawley, Calif., and Edward Rochester, Winterhaven, Calif.

Here, manganese occurs in andesitic conglomerate. Where exposed by open cuts, it is 8 ft. in thickness, strikes NE.-SW. and dips 35° SE. The ore contains a large amount of wall rock and rounded pebbles and is reported to carry 20% Mn. Idle.

Hodges Manganese Group of Claims. It comprises 4 claims situated in the Paymaster Mining District, on the northeast slope of the Chocolate Mountains, in T. 11 S., R. 21 E., S. B. M., 3 miles east of Midway Well; owner, Edward Hodges and associates, Yuma, Ariz.

A series of parallel veins of manganese occurs in andesite breccia. The veins strike N. 30° W.; dip vertical. Widths vary from 12 in. to 3 ft. Development consists of open cuts, short tunnels and shallow shafts. Two men employed on development work.

Lugo Manganese Mine. It comprises 4 claims situated in the Palo Verde Mountains, in Sec. 35, T. 9 S., R. 20 E., S. B. M., 5½ miles southwest of Palo Verde; owners, T. Lugo and P. D. McIntire, Blythe, Calif.; elevation 1000 ft.

There are 4 distinct veins on Donkey No. 2 Claim. They strike N. 55° E. to N. 60° E. and dip 60° to 70° SE. to vertical. The country rock is a dark-gray andesite. The vein material is black manganese oxides (psilomelane) calcite and fragments of wall rock. The fragments of wall rock are often impregnated by black oxide and are sometimes partially replaced by the manganese mineral. The northernmost of the veins shows two layers of ore about 2 ft. each in thickness. A short distance to the south is the most important vein on the property. This can be traced along its strike for a distance of 500 ft. The width of ore exposed is from 2 ft. to 3 ft., some of the ore being high grade but some of it being mixed with wall rock. About 100 ft. south of this vein, another outcrops for a distance of 50 ft. The vein material is calcite, associated with manganese oxides and ore of good grade has a thickness of 8 in. to 12 in. The fourth vein is 60 ft. southeast of the above-mentioned vein and is of the same character.

Development consists of shallow open cuts and short tunnels. About 150 tons of ore was shipped from the property during 1918 said to average 40% to 44% manganese.

Bibl.: Bull. 76, p. 59; State Mineralogist's Reports XVII, p. 269; XXII, pp. 265-266; U. S. G. S. Bull. 710-E.

MacDonald Group of Manganese Claims comprises 4 claims situated on the east slope of the Palo Verde Mountains, in Sec. 12, T. 9 S., R. 20 E., S. B. M., 6 miles southwest of Palo Verde; owner, Edward MacDonald, Brawley, Calif.

A series of parallel veins of manganese occurs in andesitic breccia. Veins vary in width from a few inches to 2 ft. Strike is NW.-SE., dip vertical. Development consists of open cuts. Idle.

Southern Pacific Land Company's Manganese Deposit. It comprises 320 acres situated in the Palo Verde Mountains, in the E. ½ of Sec. 33, T. 9 S., R. 20 E., S. B. M., 8 miles southwest of Palo Verde.

The manganese occurs as stringers 6 in. to 12 in. thick, these being a series of parallel veins; strike N. 70° E., dip vertical; in andesite. These stringer veins intersect a fault fissure in the andesite that strikes N. 70° W. The ore is psilomelane, associated with pyrolusite. Development consists of shallow open cuts. Idle.

Whedon Manganese Mines (Tolbard, Tres Amigos) comprise 28 claims situated in the Paymaster Mining District, on the northeast slope of the Chocolate Mountains, in Sec. 18 and 19, T. 11 S., R. 21 E., S. B. M., 4 miles east of Midway Well and 25 miles northeast of Glamis, a station on the Southern Pacific Railroad; elevation 800 ft.; owner, Whedon Manganese Mines, Inc., V. B. Whedon, president and manager, Bank of America Bldg., Beverly Hills, Calif.

This group of claims comprises those formerly known as the Tres Amigos and Tolbard claims. The Tres Amigos Mining Co. and the Tolbard Mining Co. operated the deposits from June, 1917, until November, 1918, during which period about 2000 tons of ore was mined and shipped reported to have run 43% to 45% manganese. The manganese ores on this property occur in fissure veins which traverse both igneous and sedimentary rocks. The igneous rocks consist of andesite and andesite breccia and the sedimentary beds are conglomerates whose pebbles have been derived from the andesite. The veins, of which there are several, strike N. 30° W., dip vertical. They vary in thickness from a few inches to 3 ft. and the longest ore shoot was about 400 ft. The greatest depth to which ore has been mined is about 40 ft. The ore mined varies from 40% to 46% Mn and from 2.5% to 8% silica; iron 0.90%; phosphorus .02%; BaO 10%. Psilomelane is the principal mineral with lesser amounts of manganite and pyrolusite. In a distance of about a mile, along the general strike of the veins, several veins have been discovered. They are not continuous for this distance, the largest vein having been traced for some 1200 ft. The principal veins being worked are the Marion, Black Hill No. 1, Black Hill No. 2 and Tolbard.

Development consists of numerous short tunnels, with shallow underhand stopes and tunnels. Since September, 1941, eight hundred tons of ore has been mined and shipped from the property to government stock pile at Phoenix, Arizona. The grade of ore shipped is reported to average 45% Mn. Ten men are employed.

Bibl.: U. S. G. S. Bull. 710-E; State Mineralogist's Report XXII, pp. 264-266.

NICKEL

Nickel occurs on the south slope of the Coyote Mountains. The ore is chiefly garnierite, a hydrous magnesium and nickel silicate.

Bibl.: State Mineralogist's Report XII, p. 266.

SILVER

Silver is found in the southeastern part of the county associated principally with copper, gold and lead ores. In the Paymaster District it occurs in the form of argentite. The principal production of silver has been from the Paymaster Mine where it occurs with galena and lead carbonate ores.

True Friend & Silver Moon Group of Mines. It comprises 4 claims situated in the Paymaster District, in an eastern spur of the Chocolate Mountains, in Sec. 3, T. 12 S., R. 20 E., S. B. M., 4 miles south of Midway Well and 20 miles northeast of Glamis.

The vein strikes N. 20° E. and dips 80° NW.; width 15 ft. The vein material is principally barite, stained with iron and manganese which occurs on contact of granitic gneiss and porphyry. Development consists of a tunnel driven on vein 150 ft. and a shaft 50 ft. deep. Idle.

Bibl. State Mineralogist's Report XXII, p. 267.

NONMETALLIC MINERALS

The principal nonmetallic minerals occurring in the county are: Clay, gypsum, kyanite, limestone, marble, pumice, sodium sulphate, sodium sulphur and strontium.

CLAY

Imperial County contains extensive deposits of river silt that has been used for the manufacture of common brick and tile. Extensive exposures of Tertiary clays are found on the west margin of Imperial Valley toward Carrizo Creek. These clays are many miles in extent and of great thickness.

Bibl.: State Mineralogist's Report XXII, p. 268.

Desert Gold & Aluminum Corp. Clay Deposit. It comprises 8 claims situated in the Chocolate Mountains, in Sec. 24, T. 12 S., R. 19 E., S. B. M., 1½ miles south of Imperial Gables and 12 miles northeast of Glamis; elevation 1500 ft.; owner, Desert Gold & Aluminum Corp., S. C. Hedrick, president; Alton Peterson, secretary, Seattle, Wash.

A bed of clay underlies quartzite and iron-stained gossan. The bed of clay strikes N. 30° E. and dips 50° W.; thickness 100 ft. and 200 ft. in length. Development consists of 3 shafts 30 ft. deep and a crosscut tunnel 70 ft. The clay is white in color and would be suitable for fire clay.

Analysis:	Aluminum (Al_2O_3)	36.90%
	Silica (SiO_2)	49.10%
	Lime (CaO)	3.10%
	Magnesium (MgO)	1.40%
	Iron (Fe_2O_3)	1.40%
	Soda (Na_2O)	1.50%
	Potash (K_2O)	3.70%
	Ignition loss	3.70%

Idle.

Full Moon Clay Deposit. The deposit is located on the southwestern slope of the Chocolate Mountains, in T. 10 S., R. 16 E., S. B. M., 8 miles north of Iris Siding, on the Southern Pacific Railroad. Holdings comprise 5 claims known as Full Moon Group; owner, J. Thebo, La Mesa, Calif.

The clay is a white talcose clay, showing high aluminum content. The development consists of a number of open cuts along the surface outcrop. Analysis of clay made by A. J. Foyet, Los Angeles, is as follows:

Silica (SiO_2)	27.93%
Alumina (Al_2O_3)	42.33%
Iron (Fe_2O_3)	1.92%
Lime (CaO)	0.53%
Soda (Na_2O)	0.70%
Water (combined)	12.44%
Moisture	0.70%
Sulphur anhydride (SO_3)	13.39%
Total	100.00%

Idle.

Bibl.: State Mineralogist's Report XXII, p. 269.

Jumbo Clay Deposit. It comprises 120 acres situated on the west slope of the Coyote Mountains, in Sec. 6, 7 and 8, T. 16 S., R. 9 E., S. B. M., 10 miles west of Coyote Wells and 14 miles northeast of Jacumba, 5 miles north of Dos Cabesos, a siding on the San Diego & Arizona Railroad; elevation 1500 ft.; owners, C. H. Lundsford and F. W. Sterns, San Diego, Calif.

Extensive exposures of Tertiary clays occur on the property which are of great thickness. Analysis of the clay is as follows:

Silica (SiO_2)	53.50%
Aluminum oxide (Al_2O_3)	14.10%
Iron oxide (Fe_2O_3)	3.90%
Magnesium oxide (MgO)	3.62%
Calcium oxide (CaO)	6.80%
Sodium & potassium oxides	3.98%
Loss on ignition	14.16%

Undeveloped except for trenches and open cuts. Idle.

McKnight Clay Deposit. The deposit of clay is situated on the southwest slope of the Chocolate Mountains, in Sec. 36, T. 1 S., R. 19 E., S. B. M., 10 miles northeast of Glamis, a station on the Southern Pacific Railroad; elevation 900 ft.; owner, State of California. Forty acres are under lease to J. H. McKnight, Los Angeles.

The material is a sericite mica-schist which occurs along a fault in the schist which is overlain by quartzite. Along this fault there is a well-defined shear zone which strikes E.-W. and dips 30° S. The thickness of the clay is about 50 ft. and can be traced along the shear zone for a distance of 1500 ft. The clay is pure white in color, with only a trace of iron.

Development consists of an open cut 100 ft. in length and a tunnel 40 ft. in length. When operated, several thousand tons of clay was shipped to the Vernon Potteries Co., Vernon, Calif.

Analysis of clay:	Silica (SiO_2)	70.00%
	Aluminum (Al_2O_3)	20.50%
	Potash (K_2O)	4.00%
	Soda (Na_2O)	11.56%
	Titanium (TiO_2)	0.25%
	Iron (Fe_2O_3)	0.05%
	Ignition loss	3.70%

Freight rate from Glamis to Los Angeles is $2.76 per ton. Idle.

KYANITE AND DUMORTIERITE

Kyanite (Al_2SiO_3) is an aluminum silicate of the same chemical composition as andalusite and sillimanite but crystallizing in the triclinic system. It occurs usually in long, bladed crystals, rarely terminated; hardness, 5-7; gravity, 3.56-3.67; color, blue, green and white; vitreous to pearly luster.

An extensive deposit of kyanite occurs in the Cargo Muchacho Mountains, near Ogilby and is owned and operated by the Vitrefrax Corp., of Los Angeles.

Dumortierite ($8\ Al_2O_3B_2O_3\ .6SiO_2\ H_2O$) is a basic silicate of aluminum, with boron, but crystallizing in the orthorhombic system. It occurs usually in small prisms; color, blue, dark blue and violet-red; hardness, 7; gravity, 3.22-3.43.

Dark blue boulders of dumortierite have been found in the washes in the Cargo Muchacho District and in the Picacho District, about 25 miles from Ogilby. These metamorphic minerals are found in the schists and gneisses.

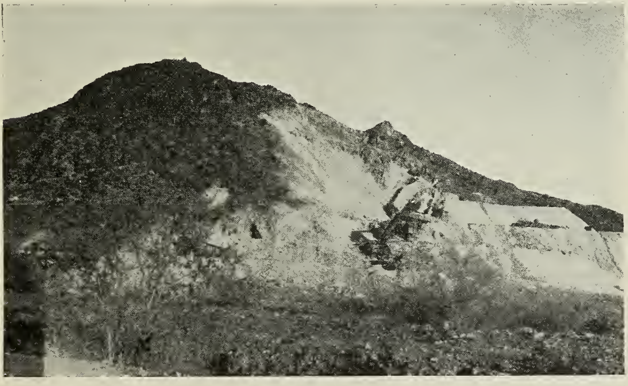

FIG. 6. Quarry—Ogilby Kyanite Deposit, Vitrefrax Corp., Ogilby, Imperial County

Ogilby Kyanite Deposits. The deposits of kyanite occur near the base of the hills on the western slope of the Cargo Muchacho Mountains, 3 miles northeast of Ogilby; elevation 500 ft. Holdings comprise 10 patented claims and 6 unpatented claims; total 320 acres. They are known as the Drifted Snow and the Blue Bird groups situated in Sec. 19 and 30, T. 15 S., R. 21 E., S. B. M.; owner, Vitrefrax Corp., 5050 Pacific Blvd., Los Angeles; Harvey M. Brown, president.

The deposit of kyanite occurs at the foot of the Cargo Muchacho Mountains. It is one-eighth of a mile in width and its outcrop can be traced for one mile in length. The rock is reported to consist of 25% kyanite in a matrix of quartz. Five thousand tons of ore mined from the deposit is reported to contain 40% kyanite. The deposit occurs in schists and gneiss, strikes N. 30° W. and dips 60° W. Analysis of the kyanite is as follows:

Silica (SiO_2)	70.00%
Aluminum (Al_2O_3)	28.00%
Iron, Fe_2O_3, Titanium TiO_2, Mg O, CaO and Alkalies	1.20%
Ignition loss	0.20%

The main quarry is located on the Blue Bird No. 2 Claim. Here the outcrop is over 200 ft. in width. Development consists of tunnels and 4 open cuts. Ore mined from main quarry is hauled to the American Minerals Company's plant located north of the property for grinding, then shipped to the company's plant in Los Angeles for the manufacture of high-grade refractories. Production amounts to 5000 tons per year.

Equipment consists of 350-cu. ft. compressor, air drills, cars and ore bins. Ten men are employed.

Bibl.: State Mineralogist's Reports XXII, pp. 269-270; XXVII, pp. 455-457.

FELDSPAR

A deposit of albite ($NaAlSi_3O_8$), soda feldspar, occurs in Pre-Cambrian gneiss and schist on the south slope of Superstition Mountains, in T. 15 S., R. 11 E., S. B. M., 15 miles southwest of Brawley. Holdings comprise 3 claims; owners, W. Graham and Henry L. Jackson, Brawley, Calif.

The vein of feldspar is 6 ft. to 18 ft. in width; strike NW.-SE. The outcrop of feldspar can be traced for a distance of 2000 ft. Developed by open cuts. Idle.

GEMS

The gem, turquoise, occurs on the eastern slope of the Chocolate Mountains, about 2 miles east of Midway Well.

Bibl.: State Mineralogist's Report XXII, p. 270.

GYPSUM

In Imperial County, there is a large deposit on the north side of Fish Mountain and another extensive deposit on the south side of Carrizo Mountain. The deposit on the northwestern edge of Fish Mountain occurs mainly as an immense deposit three miles in length from the southeast to the northwest, with an area of about 1000 acres. The Fish Mountains lie chiefly in T. 13 and 14 S., R. 9 and 10 E. The gypsum outcrops are in Sec. 19, 20, 29, 30, 32, T. 13 S., R. 9 E., S. B. M.

Carrizo Gypsum Deposit. A large deposit of gypsum occurs on the south slope of Carrizo Mountain, in T. 13 and 14 S., R. 9 E., S. B. M., 7 miles north of Carrizo Springs and 20 miles northwest of Coyote Wells. Idle.

Bibl.: State Mineralogist's Report XXII, p. 271.

Coyote Mountain Gypsum Deposit. The deposit occurs on the south slope of Coyote Mountain, 3 miles north of Coyote Wells. The gypsum is exposed over an area of about 10 acres, with an average thickness of 8 ft. Idle.

Bibl.: State Mineralogist's Report XXII, p. 271.

Pacific Portland Cement Company, Cons., W. H. McCarthy, president; J. H. McCarthy, vice president; I. S. Elliott, superintendent; offices, 111 Sutter St., San Francisco, Calif. The plant is located at Plaster City on the San Diego & Arizona Railroad, 16 miles west of El Centro. Holdings of the company comprise 1200 acres in the Fish Mountains, in Sec. 19, 20, 29, 30, 32 and 33, T. 13 S., R. 9 E., S. B. M., 26 miles northeast of Plaster City.

The gypsum occurs as an immense deposit about 3 miles in length from southeast to northwest and about one mile in width, with an average thickness of over 150 ft. The beds dip 15° to 25° W. It is stated that the gypsum mined has the most uniform grade of any deposit in the United States, the average being 95% gypsum. The deposit as proven by drill holes, may be said to contain an inexhaustible supply of commercial gypsum. Analysis of the gypsum:

Sulphuric anhydride (SO_3)	47.17%
Lime (CaO)	32.75%
Crystallized water	18.75%
Silica (SiO_2)	.92%
Iron oxide (Fe_2O_3)	.14%
Alumina (Al_2O_3)	.21%
Magnesia (MgO)	.08%

The quarry has been opened up for a distance of 3000 ft. in a northwest direction, with an average height above the floor of the quarry of 100 ft. The rock gypsum is first drilled with Armstrong churn drill and then a series of holes is blasted, breaking down a large tonnage. The broken material is loaded by a Marion steam shovel into 30-ton, steel, side-dump cars, then hauled in a train of 18 cars by locomotive, to the plant at Plaster City.

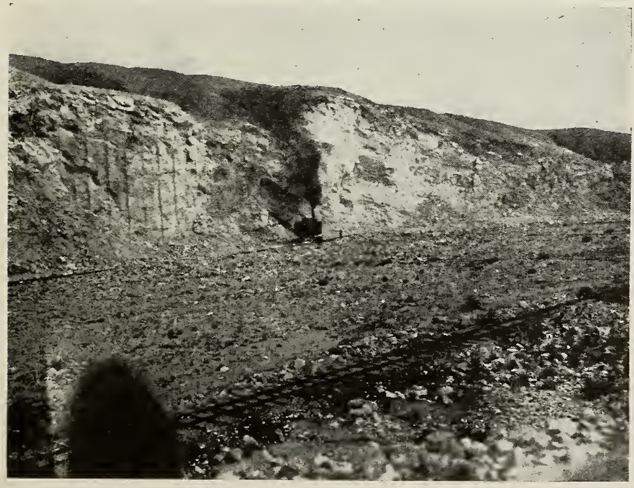

FIG. 7. Pacific Portland Cement Company's Gypsum Quarry, Fish Mts., Imperial County

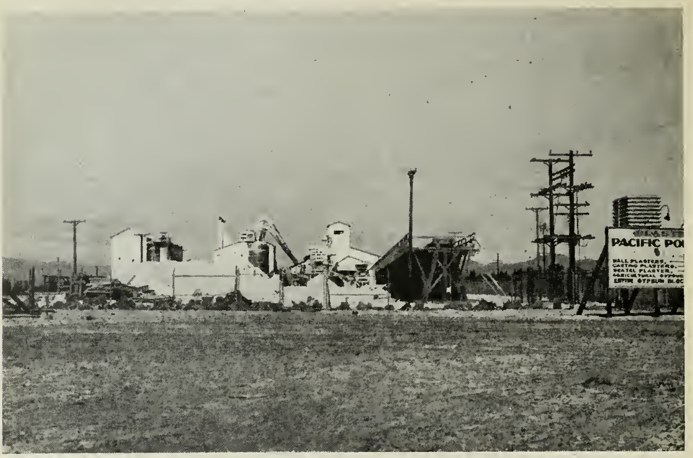

FIG. 8. Gypsum Plant, Pacific Portland Cement Co., Plaster City, Imperial County

Equipment at the quarry consists of blacksmith and machine shops, 260-cu. ft. Ingersoll-Rand compressor, driven by 25-h.p. gas engine, Marion steam shovel and one Armstrong churn drill. Six men are employed at the quarry.

The plant at Plaster City has a capacity of 300 tons per day. At the time the plant was visited, it was only being operated three days per week. Products produced were fertilizer, cement retarder, hard wall and finished building plasters, casting moulding, dental plasters. Fifteen to 20 men are employed at the plant.

Bibl.: State Mineralogist's Report XXII, pp. 271-275.

Roberts & Peeler Gypsum Deposit. The deposit is situated on the northwestern edge of the Fish Mountains, 1½ miles northwest of the Pacific Portland Cement Company's gypsum deposit, in the NW. ¼ of Sec. 18, and W. ½ of the NW. ¼ of Sec. 18, T. 13 S., R. 9 E., S. B. M., 9 miles south of Benson's Service Station, on Highway No. 78. The property comprises 3 claims, totaling 80 acres; owners, O. F. Peeler and Minnie N. Roberts, Los Angeles; under lease to Pan Chemical Co., 205 First National Bank Bldg., Pomona, Calif.; Philip J. Curran, president; Allan J. Carter, secretary; John A. Stephens, vice president and general manager.

A bed of gypsum 40 ft. to 50 ft. in thickness underlies celestite beds. The strike of the beds is north-south, dip 25° W. and is exposed for a distance of 1500 ft. This is the same quality of gypsum that is being mined by the Pacific Portland Cement Co.

LIMESTONE AND MARBLE

The principal deposits of this material in Imperial County are in the Coyote Mountains, in Sec. 22, 23, 24, 25, 26, 27, 35 and 36, T. 15 S., R. 9 E. and in the Fish Mountains in Sec. 1, 7 and 12, T. 14 S., R. 9 E., S. B. M. These deposits of crystalline limestone are extensive and due to the fact that this limestone has a low magnesium content, makes it ideal for cement manufacture. The raw materials for Portland cement are very abundant on the west side of Imperial Valley, in great deposits of Tertiary clay and crystalline limestone which are close together and close to railroad transportation.

The chief deposits of marble are in the Coyote Mountains, in T. 15 S., R. 10 E., S. B. M. The deposits are within 6 miles of the San Diego & Arizona Railroad.

Creole Marble Deposit consists of 4 claims covering outcrop of marble about 4500 ft. long and averaging 600 ft. in width, located in the NE. ¼ of Sec. 36, T. 15 S., R. 9 E., S. B. M. Here are three distinct strata of marble. The marble has a hardness of 3.5 and the colors range from blue-black, gray, white and black. The deposit is estimated to contain 3,000,000 cubic feet of commercial marble. One mile south of this deposit in Sec. 1, T. 16 S., R. 9 E. and in Sec. 35, T. 15 S., R. 9 E., S. B. M., are deposits of marbleized limestone that occur along a belt of limestone that strikes N. 30° W. and dips 70° E. The outcrops are from 100 ft. to 200 ft. in thickness and between 500 ft. and 1200 ft. in length. These deposits are estimated to contain 200,000,000 cubic feet of commercial marble. Owners are Henry L. Jackson, Brawley, and Phillip W. Knights, El Centro, Calif.

Bibl.: State Mineralogist's Reports XV, pp. 733-736; XVII, p. 238; XXII, pp. 275-277.

Jumbo Limestone Deposit. It comprises 14 claims situated on the southwest slope of the Coyote Mountains, in Sec. 31, T. 15 S., R. 9 E., S. B. M., 5 miles north of Dos Cabesos, a siding on the San Diego & Arizona Railroad and 14 miles northeast of Jacumba; elevation 1700 ft.; owners, C. H. Lunsford Estate and F. W. Sterns, San Diego.

The limestone beds strike NE.-SW. and dip 70° to the SE. The outcrop is one mile in length and one-half mile in width. The crystalline limestone is white in color. Analyses vary from 94% to 98% $CaCO_3$ and from trace of magnesium oxide to 2% MgO.

Equipment consists of loading bins, cars and tracks. Idle.

Mountain Springs Limestone Deposit. The deposit is located on the main highway from Jacumba to El Centro and is 2 miles east of Mountain Springs and 8 miles west of Coyote Wells. The belt of limestone strikes N. 30° E. and dips 60° NW. The beds of limestone are interstratified with schist. The beds have a thickness of 200 ft. The property is operated by the Tycrete Chemical Corp., Chula Vista, Calif. Six men are employed.

Waters Limestone Deposit. It comprises 7 claims located in Sec. 1, 7 and 12, T. 14 S., R. 9 E., S. B. M., 14 miles north of Coyote Wells in the Fish Mountains; owner, W. A. Waters, Pasadena, Calif.

This is a large deposit of crystalline limestone on the crest of Fish Mountains, the major portion of the limestone being in Sec. 1 and 12, T. 14 S., R. 9 E., at elevations ranging from 1000 to 1600 ft.

The belt of blue-gray limestone strikes N. 30° W. and dips 65° E. It is three miles in length and about one mile in width and exposed for a depth of 600 ft. Analysis of the limestone shows 97% to 98% $CaCO_3$, with only 0.7% $MgCO_3$. In Sec. 31 and 32, T. 13 S., R. 9 E., S. B. M. is another large deposit of blue-gray limestone that occurs on the east slope of the Fish Mountains. Idle.

Bibl.: State Mineralogist's Report XXII, p. 277.

PUMICE

Pumice is found at several places, especially interbedded with Tertiary sediments around Carrizo Creek, Superstition Mountains and east of the Salton Sea. The deposits on the shores of the Salton Sea have been worked for a number of years and have produced a considerable tonnage. The material is of the vesicular, gray variety and is sold for abrasive purposes.

Kalite Company's Pumice Deposit (California). This deposit is located in the Obsidian Buttes and Pumice Buttes, on the southeast shore of Salton Sea, in T. 11 S., R. 13, E., S. B. M., 11 miles northwest of Calipatria; owned and operated by the Kalite Co.; O. J. Salisbury, Los Angeles, from 1930 to 1935. It was then acquired by Chamberlain Co., Inc., Los Angeles, which company operated the deposit from 1935 until 1938. The deposit is worked out.

The pumice occurs on the east slope of a low, rounded hill and is interbedded in the sediments. The pumice occurs in pieces that vary in size up to 12 inches. Development consists of a number of large open cuts. Idle.

Bibl.: State Mineralogist's Reports XVII, pp. 270-271; XXII, p. 280.

PYROPHYLLITE

Pyrophyllite is a hydrous silicate of aluminum, $H_2Al_2Si_4O_{12}$. It resembles talc so closely in its properties it is frequently classed as talc. It occurs in schists and gneisses, associated with kyanite on the kyanite deposit owned by the Vitrefrax Corp., of Los Angeles, near Ogilby. It is exposed in a number of places on the Drifted Snow Group of Claims.

Bibl.: State Mineralogist's Report XXII, p. 280.

SALT

The salt production from Imperial County is obtained by evaporation from water of the Salton Sea. Two producers are under operation.

Imperial Salt Co., 4000 East Washington Blvd., Los Angeles, has a plant located on the southeast shore of the Salton Sea, 6 miles northwest of Calipatria.

The other plant is located near Mullett Island, known as the *Mullett Island Salt Works*, on the southeast shore of Salton Sea, 6 miles west of Niland. This plant is owned and operated by Reeder Salt Co., 845 El Centro St., South Pasadena, Calif.

SERICITE SCHISTS

American Minerals Co., Ogilby, Calif., has a plant 4 miles northeast of Ogilby in which they grind cyanite from the Vitrefrax deposit and sericite schist from the Western Non-Metallic Company's deposit.

Materials are hauled in by 4-ton trucks. From receiving bin, it is fed by hand to 9-in. by 16-in. jaw crusher; elevator to 2-deck vibrating screen, 10 and 16 mesh; oversize and minus 10 plus 16 to crude-ore bins; minus 16 to Sturtevant mechanical separator. All minus 80-mesh is finished product; plus 80 dropped by separator onto 40-mesh screen; minus 40 to mill; plus 40 to waste; oversize from crude-ore bin is fed to Sturtevant mill, to elevator and vibrating screens. Product is sacked by hand. Plant is run by 40-h.p. semi-diesel engine. Capacity, when grinding schist, is 3 tons per hour, cyanite 1½ tons per hr. Two men operate the plant.

Western Non-Metallic Company's Sericite Schist Deposit comprising 9 claims, is in the Cargo Muchacho Mountains, about 4 miles northeast of Ogilby; owner, Western Non-Metallic Co., Ogilby, Calif.

This deposit, which is 100 ft. or more in thickness, occurs between an impure kyanite hanging wall and an undetermined (because it has not been exposed) footwall. The kyanite is capped by an ordinary mica schist. The deposit has been mined in an open cut on the east side of the hill. This cut is 100 ft. long, 50 ft. wide and 50 ft. deep. A new pit one-quarter of a mile southwest of the old is now being developed. The material is hauled about 1½ miles north to the American Minerals Company's plant where it is ground and sacked.

SILICA

Deposits of silica (quartz) occur in the Chocolate Mountains and deposits of silica sand occur in the Coyote and Fish mountains.

Chocolate Mountains Silica Deposit. A large deposit of quartz occurs in schist in the Chocolate Mountains in Sec. 7, T. 12 S., R. 18 E., S. B. M., 10 miles north of Glamis. Holdings comprise 160 acres. The quartz is white to brown in color and is reported to show a low iron content. Owners are Charles Kurton, Bob Gunn, R. D. Glick, 1056 North 7th St., Colton, Calif.

Coyote Mountain Silica Deposit. A bedded deposit of silica sand occurs in the Coyote Mountains, in Sec. 1 and 2, T. 16 S., R. 9 E., S. B. M., 7 miles north of Coyote Wells, a station on the San Diego & Arizona Railroad; owners, Henry Jackson, Brawley, Calif., and Phillip W. Knights, El Centro, Calif. Holdings comprise 60 acres.

The bed of silica is about 50 ft. thick and can be traced for a distance of 1000 ft. The sand is clean and white and is suitable for the manufacture of glass. In 1921 and 1922, it is stated that 1200 tons was shipped to Los Angeles. Idle.

Bibl.: State Mineralogist's Reports XVII, p. 271; XXII, pp. 281-282.

Fish Mountain Silica Deposit. This deposit of silica sand is located in the Fish Mountains, in Sec. 10 and 15, T. 14 S., R. 9 E.,

S. B. M., 14 miles north of Coyote Wells; owner, W. A. Waters, Pasadena, Calif. Idle.

Bibl.: State Mineralogist's Report XXII, p. 281.

SODIUM SULPHATE

Bertram Sodium Sulphate Deposit. The deposit is situated in the Durmid Hills, northeast of the Salton Sea in the N. ½ of Sec. 19, T. 9 S., R. 12 E., and the S. ½ of Sec. 13, T. 9 S., R. 11 E., S. B. M., totaling 640 acres of patented land, 1½ miles north of Bertram, a station on the Southern Pacific Railroad; elevation 125 ft. below sea level; owner, E. N. Smith, Alhambra, Calif.; under lease to American Sulphates Co., C. D. Adams, president and manager; Mrs. C. D. Adams, secretary, Pomona, Calif. The American Sulphates Co. also have federal permits in Sec. 18 and 19, T. 9 S., R. 12 E., S. B. M. and in Sec. 14 and 24, T. 9 S., R. 11 E., S. B. M.

The deposit is mainly thenardite, an anhydrous sodium sulphate which has a crystal form distinct from that of mirabilite and not so subject to alteration on exposure to the air. Mirabilite, glauber salt, is here associated with thenardite, usually on top of the stratum of thenardite.

Recent developments have exposed an extensive deposit of blödite, hydrous magnesium and sodium sulphate, $MgSO_4$-$Na_2 SO_4$-H_2O. These parallel strata of thenardite and blödite occur in Tertiary sedimentary clay beds, shales and sandstones which are extensively folded. The general strike of these beds is N. 70° W. The dip varies from 40° N. to 65° S. The stratum of thenardite has a thickness varying from 8 in. to 3 ft. The layer of blödite has a thickness of 12 in. to 6 ft., the average thickness exposed in west workings being 5 ft. The proven area containing sodium sulphate is about one-half of a mile wide and about 3000 ft. in length. In 1923 all work was confined to the east end of

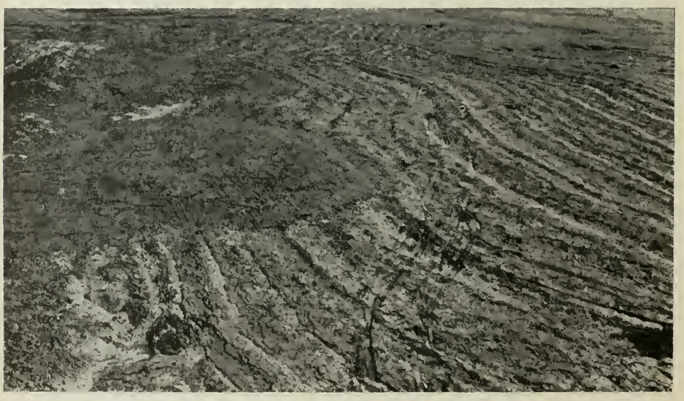

FIG. 9. Aerial view of clay beds showing folding, Bertram Sodium Sulphate Deposit. Photo by C. D. Adams, Pres., American Sulphates Co., Bertram, Imperial County

the property. Here, from an open cut 600 ft. in length and 14 ft. in depth, about 2500 tons of salt cake was extracted by E. H. Otto and Co., of San Francisco.

Analysis of the sodium sulphate by Smith-Emery Co., of Los Angeles, is as follows:

Water insoluble	trace
Iron and aluminum oxides	none
Calcium oxide (CaO)	none
Magnesium oxide (MgO)	trace
Sodium oxide (Na_2O)	43.64%
Moisture (105°)	.07%
Combined water	.12%
Chlorine (Cl)	.10%
Boric anhydride (B_2O_3)	none
Sulphuric anhydride (SO_3)	56.22%
Total	100.15%

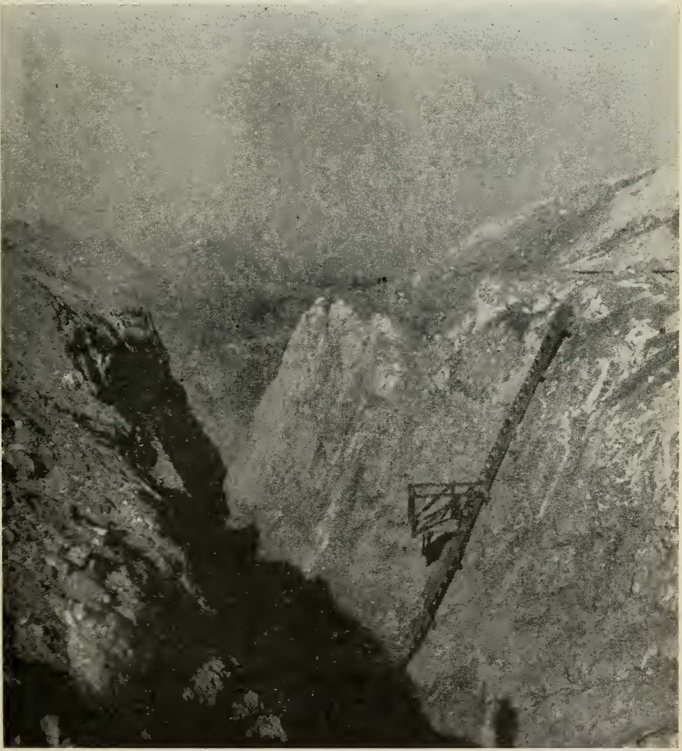

FIG. 10. Open cut—West Workings, Bertram, Sodium Sulphate Deposit, American Sulphates Co.

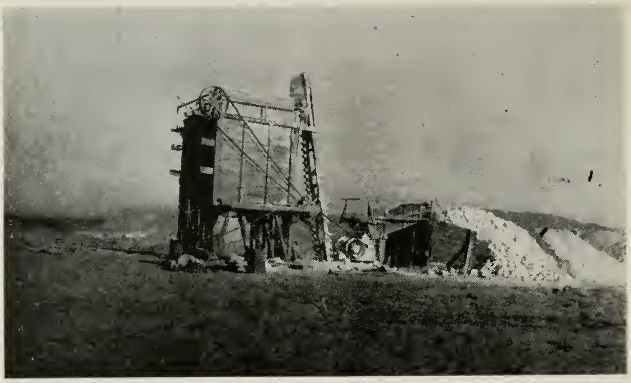

FIG 11. Crushing and Screening Plant, American Sulphates Co., Bertram, Imperial Co.

Hypothetical combination:

Sodium sulphate (Na_2So_4)	99.80%
Sodium chloride (NaCl)	.16%
Magnesium sulphate	trace
Moisture and combined water	.19%
Total	100.15%

The American Sulphates Co. started operations on the property January, 1940. All development work has been confined to the west end of the property in the N. ¼ of Sec. 19, T. 9 S., R. 12 E., S. B. M. Some 200 core-drill holes were drilled to depths of 20 ft. to 60 ft. to determine the thickness of the strata over a distance of 1000 ft. along the strike of the strata. These drill holes indicated a length of 1000 ft., with an average thickness of 5 ft. to a depth of 45 ft.; estimated tonnage of 15,000 tons of blödite and probable tonnage of 30,000 tons. The strata have been exposed by an open cut and shallow cuts for a distance of 1000 ft. On the west end of the exposed outcrop, there is an open cut 710 ft. in length to a depth of 45 ft. The average thickness was 4 ft. The strike of the strata is N. 70° W. and dip 65° S.

From these workings 250 tons of salt cake was shipped to Berk & Co., of New York. The salt cake shipped showed 4% $MgSO_4$, and with depth the magnesium content increased which caused the suspension of further shipments. On investigation by Mr. Adams, the material was found to be blödite, hydrous magnesium sulphate and sodium sulphate. Analysis showed from 10% to 20% $MgSO_4$. This high magnesium content prevented its use in making of wood pulp by the sulphite process. The company is at present experimenting on a process of solar evaporation and temperature control for the recovery of sodium sulphate.

Crushing and Screening Plant

The capacity of plant is 50 tons per day. From open pit, ore is hauled in 5-ton trucks to ramp, dumped into hopper, to 12-in. by 24-in.

Climax jaw crusher; crushed to ¾ in. to 1 in. size; elevated by bucket elevator to 42-in. diameter by 10-ft. in length trommel; screened to ⅛-in. size; oversize from trommel to 20-in. Williams hammer mill, capacity of mill being 5 tons per hr.; crushed product from Williams mill to bucket elevator; returned to trommel; the ⅛-in. product to bin, with a capacity of 100 tons. The crushed product is hauled by trucks to loading ramp at Bertram, a distance of 1½ miles.

Mine equipment consists of rotary core drill, caterpillar bulldozer, 150-cu. ft. air compressor, two 5-ton trucks. Two men are employed.

Bibl.: State Mineralogist's Report XXII, pp. 281-283.

STRONTIUM

Roberts Celestite Deposit. It comprises 3 claims located in a low hill on the north side of Fish Mountain, 1½ miles northwest of the Pacific Portland Cement Company's gypsum deposit. It is in Sec. 18, T. 13 S., R. 9 E., S. B. M., about 26 miles north of Plaster City, a station on the San Diego & Arizona R. R.; owners, David B. Roberts and O. F. Peeler, of Los Angeles; leased to the Pan Chemical Co., Philip J. Curran, president; Allan J. Carter, secretary; John A. Stephens, vice president and manager; offices, 205 First National Bank Bldg., Pomona, Calif. Chemical plant is at La Verne, Calif.

The celestite, 6 ft. to 10 ft. thick, is underlain by gypsum which apparently rests on granite. The deposit outcrops on top of a hill that rises 300 to 400 ft. above the floor of the valley. It is traceable for 1500 ft., is white to gray in color and is reported to be quite pure, running from 90% to 96% $SrSO_4$.

Development consists of 2 open cuts. The east open cut is 50 ft. in width by 100 ft. in length and 8 ft. deep. This exposes a bed of celestite 8 ft. thick. About 300 ft. west of these workings and at higher elevation, there is an open cut 50 ft. wide by 75 ft. in length and 10 ft. in depth. Ore from this cut is dumped into 10-ton bin from which is loaded trucks and hauled to Westmoreland for shipment to the Du Pont Co., of Wilmington, Delaware. It is reported that about 1000 tons of celestite has been shipped from the deposit, averaging 96% $SrSO_4$. Mine equipment consists of cars, compressor and truck. Six men are employed.

Bibl.: State Mineralogist's Reports XVII, pp. 271-272; XXII, p. 284.

SULPHUR

There are small exposures of sulphur associated with gypsum on the east slope of the Coyote Mountain and also on the southeastern slope of the Chocolate Mountains.

Coyote Mountain Gypsum & Sulphur Deposit is in the SE.¼ of Sec. 6, T. 16 S., R. 10 E., S. B. M., about 7 miles north of Coyote Wells, a station on the San Diego & Arizona Railroad; elevation 500 ft.; owner, Mrs. Anna Dillon, of Los Angeles; leased to Vesubio Mining Corp., Ltd., Louis F. Vremsak, Calexico, Calif.

This is really an impure gypsum deposit which contains from 2% to 5% sulphur. It is on the northeast slope of Coyote Mountain where it has been opened by a hillside cut which consists of two benches, one about 40 ft. above the other. The total height of face of the two benches is approximately 70 ft. The length of the cut is about 100 ft.

This brown, iron-stained, impure gypsum is mined and hauled to the company's plant in Calexico only as it is needed for fertilizer. Four men work intermittently on the deposit.

Bibl.: State Mineralogist's Report XXII, pp. 284-285.

Full Moon Sulphur Deposit. It is located on the southwestern slope of the Chocolate Mountains, in Sec. 36, T. 10 S., R. 16 E., S. B. M., 8 miles north of Iris Siding, on the Southern Pacific Railroad. Holdings comprise 5 claims known as Full Moon Group.

Here, pure sulphur occurs in seams in tufa. Development consists of open cuts, shallow shafts and short tunnels. Idle.

Bibl.: State Mineralogist's Report XXII, p. 285.

CARBON DIOXIDE GAS

Salton Sea Carbon Dioxide Gas Field*

The first production of Carbon dioxide gas here was in 1933, from wells drilled southeast of the Salton Sea, about 7 miles southwest of Niland. On November 1, 1934, a dry-ice plant was put into operation for the condensation of the carbon dioxide from the above wells. At present, there are two companies producing carbon dioxide from wells in the Salton Sea Gas Field. The field is located on the desert plain southeast of the Salton Sea, southwest of Niland, a station on the Southern Pacific Railroad.

The production of this gas is from an area two miles in width and three miles in length. The general strike of the field is north and south. The productive gas sand has been proved by wells to a depth of 635 ft. The thickness of the sand is 35 ft. and first encountered at a depth of 600 ft.

There are 15 producing wells in the field, which at present are reported to be yielding 126,000 M.C.F. of CO_2 gas per month. The first well in the field was drilled by the Salton Sea Chemical Products Corp., Carl M. Einhart, president and manager, in the latter part of 1932. The gas production came from a depth of 590 ft. The well produced 10,000 cu. ft. of gas per day. Gas tested 93% CO_2, with a small amount of water. The well is located in Sec. 12, T. 11 S., R. 13 E., S. B. M.

National Dry Ice Corp., W. E. Morse, president; Barney Wright, secretary; L. B. Fade, general superintendent, 1225 East 8th St., Los Angeles. The company has 7 producing wells in Sec. 2, T. 11 S., R. 13 E., S. B. M., 4½ miles southwest of Niland. These wells have an average depth of 635 ft. The productive sand is 35 ft. thick. The monthly production is 58,000 M.C.F. The gas flows through 3½ miles of 4½-in. pipe line to the dry-ice plant at Niland. In the plant at Niland, the gas is compressed and liquefied for manufacture of dry ice. It requires 20,000 cu. ft. of carbon dioxide gas to produce one ton of dry ice. The capacity of the plant is 25 tons of dry ice per day. Six men are employed.

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* See also under Special Articles.

DIVISION OF MINES
WALTER W. BRADLEY, STATE MINERALOGIST

STATE OF CALIFORNIA
DEPARTMENT OF NATURAL RESOURCES
KENNETH I. FULTON, DIRECTOR

PLATE I

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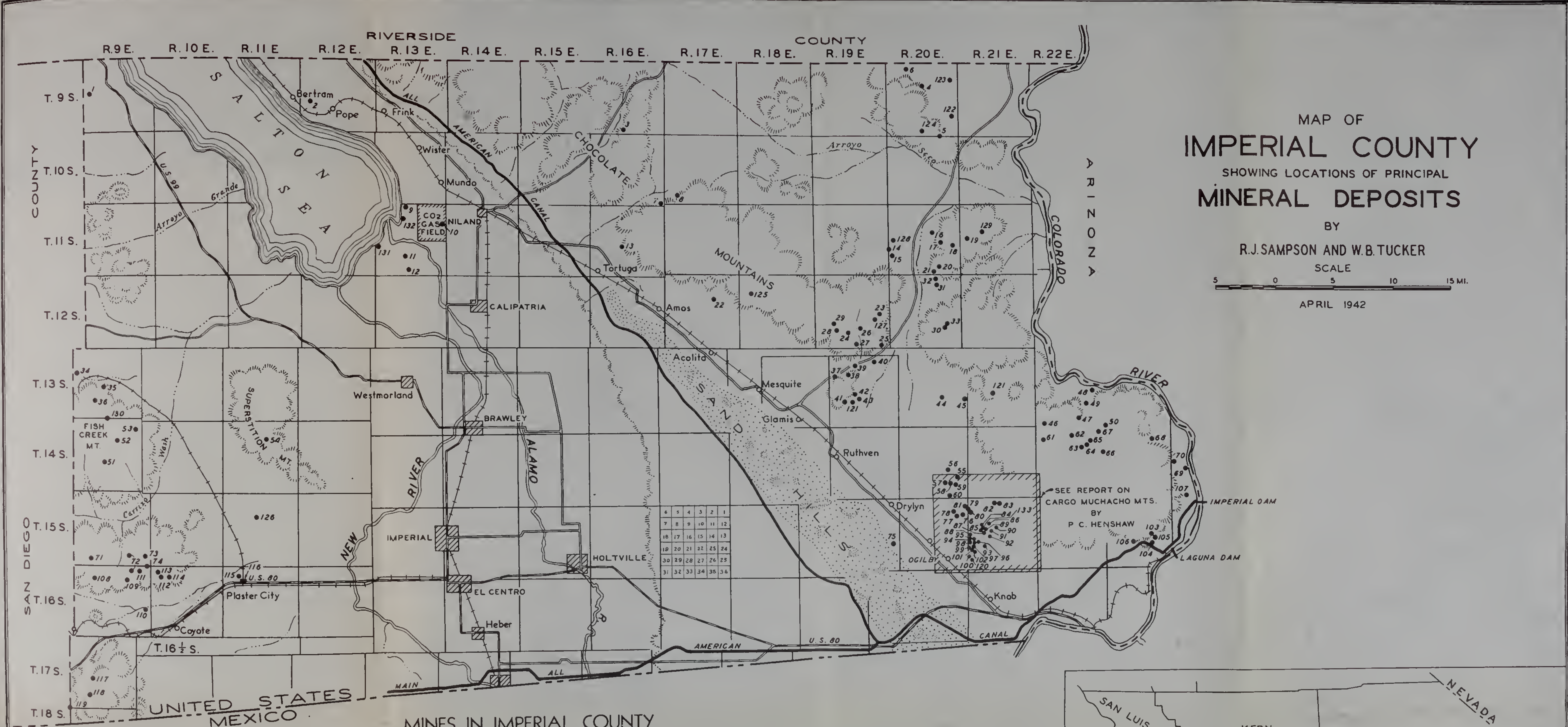

MAP OF IMPERIAL COUNTY SHOWING LOCATIONS OF PRINCIPAL MINERAL DEPOSITS

BY
R. J. SAMPSON AND W. B. TUCKER

SCALE
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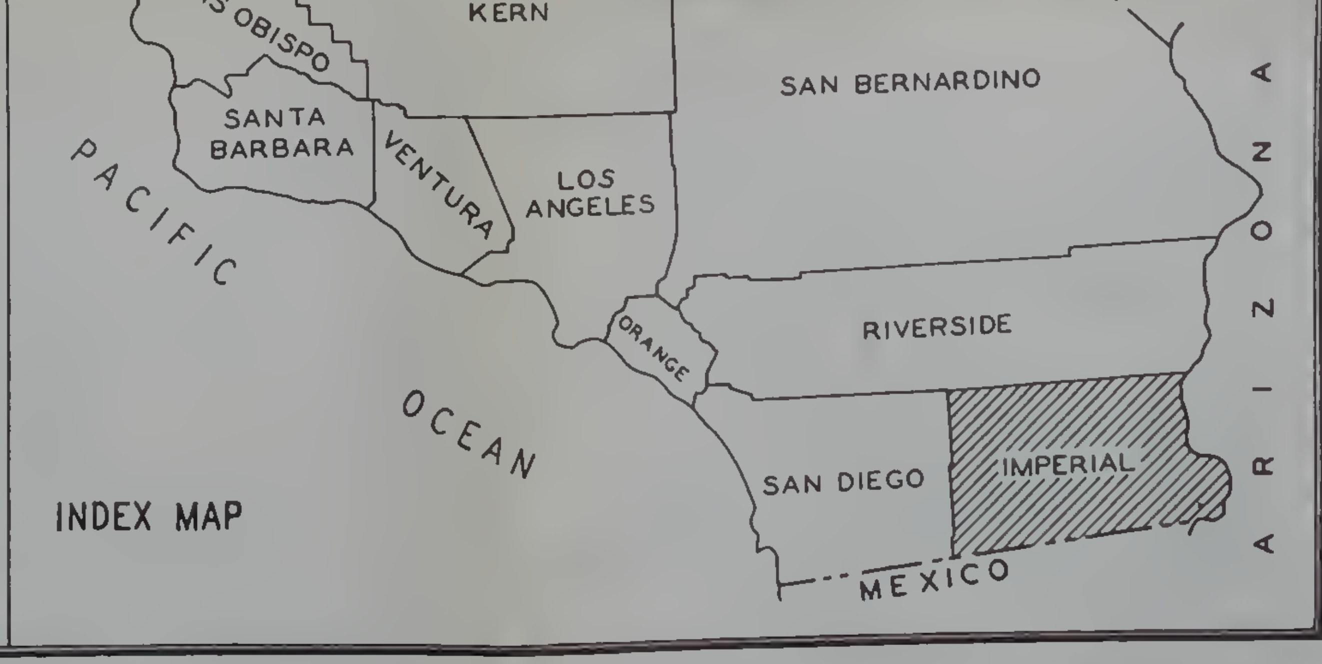
APRIL 1942



INDEX MAP

MINES IN IMPERIAL COUNTY

No.	Name	Acres	Sec.	Twp.	Range
1	Lakeview	20 A	18	9 S	9 E
2	Bertram Sodium Sulphate	320 A	19	9 S	12 E
3	Churchill Iron Deposit	20 A	33	9 S	16 E
4	Ebony Manganese Deposit	60 A	9	9 S	20 E
5	Lugo Manganese		35	9 S	20 E
6	Chocolate Drop Mine (Tolliver)	20 A	5	9 S	20 E
7	Full Moon Sulphur Deposit	100 A	36	10 S	16 E
8	Peg Leg Mine	20 A	31	10 S	17 E
9	California Pumice Deposit		4	11 S	13 E
10	Salton Chemical Products Co. CO_2 Gas Well No. 1		12	11 S	13 E
11	Salton Chemical Products Co. Well No. 2		28	11 S	13 E
12	Brand & Stevens Pumice	160 A	33	11 S	13 E
13	Silver Reef Mines	60 A	21	11 S	16 E
14	Paymaster Mine	200 A	24–25 19–30	11 S	19 E 20
15	Big Chief Group of Mines	80 A	30	11 S	20 E
16	Midway Mines	80 A	15	11 S	20 E
17	Clay Deposit	80 A	23	11 S	20 E
18	Silver Shaft Mines (Ag)	40 A	24	11 S	20 E
19	Black Hill Manganese (Telbard)		8 & 19	11 S	21 E
20	Benton	20 A	35	11 S	20 E
21	Golden Eagle	20 A	34	11 S	20 E
22	Mary Lode Mine	60 A	14 & 15	12 S	17 E
23	Clay Deposit, Desert Gold and Aluminum Corp.	60 A	24	12 S	19 E
24	Hematite Group (Gold-Iron)	40 A	28	12 S	19 E
25	McKnight Clay Deposit	160 A	36	12 S	19 E
26	Mesquite Lode Mine	180 A	27	12 S	19 E
27	Walking Stick Mine	20 A	34	12 S	19 E
28	Yellow Aster Mine	20 A	29	12 S	19 E
29	Yellow Dog Group	40 A	20–29	12 S	19 E
30	Cow Mans Group (Copper)	80 A	26	12 S	20 E
31	Gold Basin Mine (Au)	80 A	3	12 S	20 E
32	True Friend & Silver Moon (Au & Ag)	80 A	3	12 S	20 E
33	Volunteer Copper Mine	160 A	26	12 S	20 E
34	Roberts Strontium Sulphate Deposit	80 A	18	13 S	9 E
35	Empire Marble Mt. & Mammoth (Limestone)	320 A	21	13 S	9 E
36	Pacific Portland Cement Co. (Gypsum)	1200 A	19–20 29–30 32–33	13 S	9 E
37	Land Group of Lode & Placer Claims	400 A	7	13 S	19 E
38	Copenhagen Placer Mine	80 A	4	13 S	19 E
39	Desert View Mine	40 A	4	13 S	19 E
40	Pirinca Mine	80 A	3	13 S	19 E
41	Gold Basin Rand Placers	800 A	20	13 S	19 E
42	Erma Mines (Lode Gold)	240 A	21	13 S	19 E
43	Desert Gold & Aluminum Co. Mesquite Placers	800 A	21	13 S	19 E
44	Prosperity Mine	20 A	22	13 S	20 E
45	Ruby Mine	20 A	24	13 S	20 E
46	Kohl Placer Mine	20 A	31	13 S	22 E
47	Georgia Placers (Pat)	160 A	34	13 S	22 E
48	Pichacho (Gulch) Basin Placers (Pat.)	360 A	23–26 27–34	13 S	22 E
49	Crescent Placers (Pat.)	100 A	23 26	13 S	22 E
50	La Colorado Mines				
51	Campbell Gypsum Claims (Pat.)	160 A	21	14 S	9 E
52	Fish Mt. Silica Sand Deposit	20 A	10	14 S	9 E
53	Waters Limestone Deposit	1200 A	1 & 12	14 S	9 E
54	Superstition Mt. Feldspar Deposit	80 A	10	14 S	11 E
55	La Colorado Mines (Au)	240 A	25 & 26	14 S	20 E
56	Imperial Lode Mines (Au)	80 A	23	14 S	20 E
57	Telluride Mines (Au)	140 A	26	14 S	20 E
58	Gold Leaf Group Mines (Au)	80 A	26	14 S	20 E
59	Golden King Mine (Au)	20 A	26	14 S	20 E
60	Coffey Mine (Au)	120 A	35	14 S	20 E
61	Rainbow Mines (Au)	40	7	14 S	22 E
62	Pichacho Basin Gold Mines (Pat.)	720 A	3–4 7–10	14 S	22 E
63	Helen Group Mines	80 A	10	14 S	22 E
64	Mayflower Group of Mines	40 A	11	14 S	22 E
65	Queen Sabe Group of Mines	80 A	11	14 S	22 E
66	Mendeville Group of Mines	40 A	13	14 S	22 E
67	Pichacho Copper Mines	160 A	1	14 S	22 E
68	El Lucero Mines (Au)	100 A	10	14 S	23 E
69	Hess Placer Mines (Au)	60 A	29	14 S	24 E
70	Yellow Dog Mine (Au)	20 A	30	14 S	24 E
71	L & S Limestone Deposit	160 A	31	15 S	9 E
72	Columbia Cement Co.'s Limestone Deposit	8000 A	26–35	16 S 15 S	9 E
73	Craols & Creole Ext. Marble Deposit	80 A	25–36	15 S	9 E
74	Southern Calif. & Development Co. Marble Deposit	80 A	36 1	15 S 16 S	9 E
75	Coon Placer	20 A	24	15 S	19 E
76	Desert King Mine	80 A	12	15 S	20 E
77	Bottle Neck Group	80 A	11 12	15 S	20 E
78	Fifty-seven Group	80 A	11	T 15 S	20 E
79	Golden Cross Mines (Tumco)	340 A	1–12 6–7	T 15 S	20 E 21
80	Sovereign Mines (Gold Bug)	240 A	1–12 6–17	15 S	20 E 21
81	Golden Queen Mine	60 A	1–12 6–17	15 S	20 E 21
82	Leapyear Group	80 A	4	15 S	21 E
83	Pay Streak	20 A	4	15 S	21 E
84	Peggy Claim	20 A	17	15 S	21 E
85	Prometheus Claim	20 A	17	15 S	21 E
86	Butterfly Group of Mines	140 A	17	15 S	21 E
87	Ogilby Group of Mines	140 A	17	15 S	21 E
88	Big Four Group of Mines	40 A	18	15 S	21 E
89	American Girl Mines (Pat.)	320 A	17	15 S	21 E
90	Guadalupe Mine (Pat.)	20 A	16	15 S	21 E
91	Pasadena Mines (Pat.)	40 A	16	15 S	21 E
92	Occidental Cons. Mines (Pat.)	141 A	21	15 S	21 E
93	Cargo Muchacho Mines (Pat.)	40 A	29	15 S	21 E
94	Padre-Madre Mines (Pat.)	60 A	19–20	15 S	21 E
95	Salamanca Cons. Mines (Pat.)	40 A	18	15 S	21 E
96	Drifted Snow Group (Pyrophyllite & Cyanite) (Pat.)	40 A	19	15 S	21 E
97	Blue Bird Group of Mines (Ogilby Cyanite) (Cyanite)	160 A	30	15 S	21 E
98	Blossom Mine	160 A	19	15 S	21 E
99	Desert View Placer Claims	40 A	19	15 S	21 E
100	Select Lode Mine	20 A	30	15 S	21 E
101	San Francisco Lode Mine	20 A	19	15 S	21 E
102	Mammoth Group of Mines	40 A	20	15 S	21 E
103	Duncan Mine	100 A	23	15 S	23 E
104	Laguna Placers	40 A	23	15 S	23 E
105	Trio Mine	40 A	23	15 S	23 E
106	Potholes Placers	80 A	21	15 S	23 E
107	Sinafer Mine-Buena Vista	20 A	5 & 8	15 S	24 E
108	Jumbo Vermiculite & Clay Deposit	120 A	6–5 7–8	16 S	9 E
109	Copper Contact Mine (Pat.)	20 A	10–11	16 S	9 E
110	Coyote Mt. Gypsum Deposit	20 A	24	16 S	9 E
111	Coyote Mt. Silica Sand Deposit	20 A	1–2	16 S	9 E
112	Coyote Mt. Sulphur & Gypsum Deposit	S.E. ¼ 20 A	6	16 S	10 E
113	Wedge Lode Claim (Cu)	20 A	6	16 S	10 E
114	Sunshine Placer Gypsum	20 A	6	16 S	10 E
115	Shell Group Placer Mines, Silica and Feldspar	40 A	5	16 S	11 E
116	Imperial Gypsum Mellite	10 A	8	16 S	11 E
117	Red Desert Mine (Feldspar)	20 A	21	17 S	9 E
118	Mountain Springs Limestone Deposit	160 A	28	17 S	9 E
119	Southern Star Mine (Zinc)	80 A	31–36	17 S	9 E
120	Big Bear & Little Bear	40 A	30	15 S	21 E
121	Big Three Mine	20 A	21	13 S	21 E
122	Desert Bloom Manganese Claims	100 A	24	9 S	20 E
123	MacDonald Manganese Claims	80 A	12	9 S	20 E
124	Southern Pacific Land Co.'s Manganese Deposit	320 A	33	9 S	20 E
125	Chocolate Mtn. Silica Deposit	160 A	7	12 S	18 E
126	Superstition Mtn. Feldspar Deposit	60 A	?	15 S	11 E
127	Silver King Mine	40 A	23	12 S	19 E
128	Homestake Mine		19?	11 S	20 E
129	Hodges Manganese Mine		16	11 S	21 E
130	Carrizo Gypsum Deposit		34 3	14 S 15 S	9 E
131	Imperial Salt Company		19	11 S	13 E
132	Reeder Salt Company		9	11 S	13 E
133	Sericite Schist Deposit			15 S	21 E

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Natural Carbonic Products, Inc., W. L. Benson, vice president and manager; Max Cawchon, superintendent, 748 East Washington Blvd., Los Angeles.

The company has drilled 15 wells, 8 of which are producing, located in Sec. 1, 2, 11, 13 and 14, T. 11 S., R. 13 E., S. B. M., 5 miles southwest of Niland. The producing wells have been drilled to depths of 635 ft. The productive sand is 35 ft. in thickness. The monthly production of carbon dioxide gas from 8 wells is 68,000 M.C.F. The production comes from two areas about 1½ miles apart. The north area is in the SE.¼ of Sec. 2 and the SW.¼ of Sec. 1 and the NE.¼ of Sec. 11, T. 11 S., R. 13 E., S. B. M., and the south area is confined entirely to the NW.¼ of Sec. 13 and 14, T. 11 S., R. 13 E., S. B. M. The dry-ice plant is located in the NW.¼ of Sec. 13, T. 11 S., R. 13 E., S. B. M., and has a daily capacity of 20 tons of dry ice. Eight men are employed.

GEOLOGIC BRANCH

CURRENT NOTES

By Olaf P. Jenkins, Chief Geologist

RECENT PUBLICATION

A new State map "Economic Mineral Map No. 3, Chromite," is now ready for distribution by the Division of Mines. This map shows the locations of all the known deposits of chromite in California, more than eleven hundred of them, classified in a four-fold manner according to past production. In the margins of the map are descriptions, charts, index maps, lists, and legends which tell the story of the chromite industry, its history, mineralogy, geology, production, and significance, in a condensed but readily available manner. The three State mineral maps, quicksilver, chromite, and oil and gas, have proved to be very highly desired by Federal engineers during this time of war. The maps are drawn on a reduced base of the Geologic Map of California.

IN PREPARATION

Economic Mineral Maps Nos. 4 and 5, one on manganese and the other on tungsten, are now being prepared. All available data for these maps have not yet been received.

IN PRESS

Part Three, "Descriptions of Individual Oil and Gas Fields," of Bulletin 118, "Geologic Formations and Economic Development of the Oil and Gas Fields of California" is now in the page-proof stage. The preparation of Part Four, "Glossaries, Bibliography, and Index," is nearing completion. It is hoped that these parts will be ready for distribution late in the Fall.

GEOLOGY AND MINERAL DEPOSITS OF THE CARGO MUCHACHO MOUNTAINS, IMPERIAL COUNTY, CALIFORNIA*

By PAUL C. HENSHAW

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[*] Minor thesis submitted in partial fulfillment of the requirements for the degree of PhD., Balch Graduate School of the Geologic Sciences, California Institute of Technology, Pasadena. Manuscript submitted for publication September 12, 1940.

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ABSTRACT

The study of the Cargo Muchacho Mountains presents the first account of the geology of southeasternmost California. In these mountains pre-Mesozoic kyanite schist and arkosite are intruded by a series of granitoid rocks probably Mesozoic in age. The two youngest rocks of this series were formed by granitization of arkosite. Andesite dikes of minor importance intruded the area probably in Tertiary time. Remnants of a once extensive flow of olivine basalt cover a few outlying hills. Alluvial deposits of three distinct ages occur in the area. Two of these, which are prebasalt in age, offer evidence that the Colorado River formerly flowed through the region.

The Cargo Muchacho Mountains constitute an important gold-mining district. The occurrence of the ore is shown to have been controlled by the regional structure. The ore deposits are mesothermal and are locally characterized by extreme alteration of the wall rock. Kyanite and sericite are also mined in the district. The record of mining activity and production of the district is brought up to date.

INTRODUCTION

LOCATION AND EXTENT OF AREA

The Cargo Muchacho Mountains are defined as the small range, including outlying hills, which cover the central portion of the northern half of the Yuma quadrangle, California-Arizona. These mountains lie immediately to the northeast of the town of Ogilby on the Southern Pacific Railroad line. Their southeastern extremity is about 9 miles NNW of Yuma, Arizona. The area which has been mapped geologically (Fig. 1) is located approximately between W. Longitude 114° 42′ 00″ to 114° 50′ 30″ and N. Latitude 32° 48′ to 32° 56′.

SETTLEMENT AND INDUSTRIES

The principal industries carried on in the area are the mining and milling of gold ores. At the height of its development in the latter part of the nineteenth century, the town of Hedges supported a population of several thousand. It now numbers about thirty. When work revived recently at the American Girl mine, the town of Obregon temporarily attained a population of over 300 inhabitants. The town of Ogilby has a population of about 100.

ROUTES OF ACCESS AND TRANSPORTATION

The main line of the Southern Pacific Railroad passes through Ogilby which lies by rail about 15.5 miles from Yuma and 250 miles from Los Angeles.

An improved county road leads northward to Blythe from a point on U. S. Highway 80 just east of the Sand Hills and about 12 miles west of Yuma. Ogilby lies on this county road, 4 miles north of U. S. Highway 80. An improved road connects Ogilby with the town of Obregon. Around the mountains is a network of unimproved roads leading in all directions between mines, prospects, and main roads.

PREVIOUS GEOLOGICAL WORK IN THE AREA

Although mining has been carried on in the Cargo Muchacho Mountains ever since the latter part of the eighteenth century, no detailed geological map has been made of the district. A few brief geological descriptions of the area have appeared in the broader surveys of the region.

In 1853 W. P. Blake, geologist in Lieut. Williamson's Pacific Railroad Exploration party, visited the south end of the Cargo Muchacho Mountains. He reported [1] that the rock consists of ''compact gneiss or gneissose granite. . . . Several white quartz veins from three inches to a foot or two in thickness were seen.'' Also Blake noted the desert pavement of ''rounded agates and carnelians, and a mass of rolled and water-worn flint, which contained small fossil shells, apparently carboniferous or cretaceous.''

J. S. Brown of the U. S. Geological Survey carried on field work in the Salton Sea Region during the winter of 1917-1918. His Water Supply Paper,[2] covering over 10,000 square miles in southeastern California, necessarily makes only the broadest generalized statements concerning the geology of any given locality in the region. He attributes the granites and schists of the Cargo Muchacho range to the oldest series of Pre-Cambrian rocks in the district. As evidence for this conclusion Brown states [3] that these rocks have suffered the greatest metamorphism, and have been intruded or overlain by all other series of the region; that they are similar to the Pre-Cambrian rocks of the Grand Canyon and other parts of Arizona; and that, although thick series of sedimentary beds are exposed, no fossils have ever been found within them.

Reports of the California State Mineralogist, with their accounts of mining activity, aided greatly in surveying the history of the Cargo Muchacho district. The geological descriptions, however, which are included in these reports, are very sketchy and include little material of value.

A series of private reports on the American Girl mine is limited in subject almost entirely to problems regarding the economics of mining and milling. The few statements regarding the geology of the mine are compiled in a report by Marshall Draper.[4] These statements consist of guesses as to the metamorphic nature of the wall rock, brief descriptions of the southward-dipping attitude of the main fault, and mention of the sulphide nature of the mineralization.

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[1] Blake, Wm. P. Geological Report (Williamson's reconnaissance in California). U. S. Pacific R. R. Expl. vol. 5, 1856.

[2] Brown, J. S. The Salton Sea Region, California. U. S. G. S. Water Supply Paper 497. 1923.

[3] Brown, J. S. *op. cit.* p. 43.

[4] Draper, M. Private report on the American Girl mine. 1911.

Field work by the writer was begun in June 1937 and continued at intervals during 1938 and 1939. In all, the writer spent a little more than three months in the area.

PURPOSE AND SCOPE OF PRESENT WORK

The purpose of the writer's geological work in the Cargo Muchacho mining district was to assemble general facts regarding the geology and mineral deposits of the whole region, and to make a detailed study of the American Girl mine.

The area was mapped geologically on an enlargement taken from the Yuma quadrangle of the Topographic Atlas of the United States. All important mineral deposits of the area were examined. Faults, wallrock alteration, and ore of the American Girl mine were studied in considerable detail.

The geology of the kyanite-bearing Vitrefrax formation presents some of the most interesting problems of the whole area. The notes on this formation included below do not pretend to offer an adequate discussion of the complexities involved. The formation has been mentioned by way of completing the picture of the regional geology. It has no direct bearing on the metallization of the district, which is the main concern of this thesis.

ACKNOWLEDGMENTS

The writer was ably assisted in the field by Messrs. H. Victor Church, William M. Fiedler, and Howard Smith.

To all the mine owners, managers, engineers and other men interested in mining in the Cargo Muchacho district, my sincere thanks are due for their cordial cooperation. Particularly do I desire to express my appreciation for the many courtesies and sincere support extended by the owners and staff of the American Girl mine.

To Doctor Ian Campbell and Doctor H. J. Fraser of the California Institute of Technology, who supervised the field work and critically read the manuscript, I am deeply grateful.

SURFACE FORMS AND DRAINAGE

The Cargo Muchacho Mountains are low but extremely rugged. The range rises sharply above an alluvial fan which is continuous with the gently sloping surface of the Colorado River delta. The range is divided almost evenly in half by the deep east-west Obregon Valley, the highest point of which lies less than 900 feet above sea level.

The highest peak of the district (2,225 feet elevation) lies in the northern half of the range. This northern portion of the mountains includes a considerable area of high, rugged hills to the east. Stud Mountain (2,130 feet elevation) dominates the southern half of the range. Both the northern and southern halves are dissected by a number of deeply incised valleys which contribute to the extreme ruggedness of the country. A compact group of hills lies about a mile to the south of the range.

The drainage divide between the Colorado River and the Salton Sea Basin passes down the crest of the range from northeast to southwest. Through the outlying hills to the northeast and to the south of the range are cut valleys which drain away from the main mountain mass. No perennial streams or flowing wells exist in the area.

CLIMATE

The climate of the Cargo Muchacho district is typical of the Sonoran Desert region. According to records kept at Yuma[5] for the past 53 years the mean annual temperature is 71.9° Fahrenheit with an absolute maximum of 120° and an absolute minimum of 22°. July is normally the hottest month.

The mean annual precipitation at Yuma is 3.38 inches. Ogilby has a mean annual precipitation of approximately 1.1 inches.[6] In summer rain often falls in violent local showers which in a few minutes change dry arroyos into raging torrents.

Smith[7] states that the natural evaporation possible at the Yuma Citrus Station, 8 miles southwest of Yuma, amounts to 121.4 inches of water per year.

Records kept at Yuma for 61 years indicate a prevailing north wind for the winter months and a west to southwest wind for the rest of the year.

FLORA AND FAUNA

On the dry rocky mountain slopes, pediments and alluvial slopes, scattered barrel cactus, cholla, ocotillo, and creosote are present. Paloverde and ironwood flourish in the dry washes. Near rock tanks and charcos which are able to hold water for long periods of time between rains, mesquite and reedy grasses maintain a precarious existence.

Animals are very scarce in the Cargo Muchacho Mountains. Small mammals, buzzards, quail, hummingbirds, lizards, rattlesnakes, and a few insects make up the fauna.

HISTORICAL SKETCH

For an account of the early explorers who passed through the Yuma region, the reader is referred to the excellent condensation of F. L. Ransome's history of Arizona modified by Kirk Bryan and published in Bryan's memorable paper on *The Papago Country, Arizona.*[8]

The best bibliography of the history of exploration of the Colorado Delta region is the annotated and classified bibliography by Godfrey Sykes.[9]

The Yuma region was first visited by the Spaniards in 1540. Occasionally, explorers and missionaries visited there during the next

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[5] Weather Bureau Bulletins. U. S. Department of Agriculture.

[6] Brown, J. S. The Salton Sea Region, California. U. S. G. S. Water Supply Paper 497, p. 13. 1923.
McAdie, A. G. Climatology of California. U. S. Dept. Agr. Weather Bureau Bull. L. 1903.

[7] Smith, H. V. Climate of Arizona. Univ. of Arizona. Exp. Sta. Bull. 130. 1930.

[8] Bryan, Kirk. The Papago Country, Arizona.
Ransome, F. L. Historical Sketch of Arizona. U. S. G. S. Water Supply Paper 499, pp. 3-23. 1925.

[9] Sykes, Godfrey. The Colorado Delta. Amer. Geographical Society Special Pub. no. 19. 1937. Also Carnegie Instn. of Wash. Pub. no. 460. 1937.

225 years. With the establishment of a short-lived settlement from 1780-81 mining was first carried on in the region.[10] The rich placer deposits at the Potholes on the west bank of the Colorado River near the site of Laguna Dam were worked. At the same time mining activity extended to the Cargo Muchacho district, and centered round placer grounds of Jackson Gulch and rich oxidized ores of Madre Valley.

Mining activity in the Cargo Muchacho district was resumed after the establishment of the Mexican Republic. Evidence of old Mexican workings and arrastres is abundant. Reputedly it was at this time that two young Mexican lads, who were playing at prospecting, in imitation of their fathers, came into camp one evening with their shirts loaded with gold. From this incident the district received its name Cargo Muchacho or Loaded Boy.

During the period of Mexican occupation American explorers began to take interest in the region of the lower Colorado. After the Mexican war, Yuma assumed importance as a fort and way station along the southern route from the east to California. American miners began to work in the Cargo Muchacho district.

The end of the Civil War applied a major stimulus to mining throughout the Southwest. Mining in the Cargo Muchacho district was established on a firm basis when in 1877 the Southern Pacific Railroad between Yuma and the coast was completed.

Additional bibliographic material is cited below.[11]

PRODUCTION[12]

Figures for the total mineral production of the Cargo Muchacho mining district for years prior to 1892 are very incomplete. For the most part they are concealed in the returns for the whole of old San Diego County. Reliable figures give a minimum total of almost $2,500,000. Conservative estimates indicate a production of more than $4,000,000 worth of gold, of which $2,500,000 to $3,000,000 were derived from the Golden Cross group of claims alone.

PETROLOGY

Metamorphosed sediments, granitoid intrusives, volcanics, and alluvium comprise the bulk of the rocks which occur in the Cargo

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[10] Browne, J. Ross. Reports upon the Mineral Resources of the United States, p. 13. Gov't Printing Office, Wash. 1867.

[11] Bolton, H. E. Kino's Historical Memoir of the Pimeria Alta. Cleveland. 1919.
Emory, W. H. Notes of a military reconnaissance from Fort Leavenworth, in Missouri, to San Diego, California. 30th Cong. 1st session. S. Ex. Doc. 7. (H. Ex. Dec. 41), pp. 1-416. 1848.
Guinn, J. M. A History of California, p. 161. Calif. Hist. Soc. 1907.
Farish, T. E. History of Arizona, vol. 3, p. 251. 1916.
Calif. State Mineralogist's Report, vol. 14, p. 725. 1913-14.

[12] Bibliography of Production Statistics:
Browne, J. R. Mineral resources of the United States. Gov't Printing Office, Washington. 1867.
Browne, J. R. Mineral resources of the Pacific States and territories. Gov't Printing Office, Washington. 1868.
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Director of the Mint U. S. Treasury Department. Production of the precious metals in the U. S. 1881-1909.
Raymond, R. W. Mineral resources west of the Rocky Mountains. Gov't Printing Office, Washington. 1869-1876.
U. S. Bureau of Mines. U. S. Department of Commerce. Mineral resources of the U. S. Washington. 1924-1931. Mineral yearbook-review. Washington. 1932-1933.
U. S. Bureau of Mines. U. S. Department of Interior. Minerals yearbook-reviews. Washington. 1933-1939.
U. S. Geological Survey. Mineral resources of the U. S. Washington. 1882-1923.

Muchacho district. The areal geology and a structure section are given in Plate II.

TABLE 1

GOLD PRODUCTION OF THE CARGO MUCHACHO MINING DISTRICT*

1892	$60,000	approximate
1893	24,374	
1895	225,000	approximate
1897	300,000	approximate
1898	350,000	approximate
1899	100,000	approximate
1905	94,299	
1911	98,044	
1913	31,794	
1914	219,389	
1915	14,411	
1916	23,493	
1917	924	
1924	259	
1926	325	approximate
1927	260	
1930	148	
1931	649	
1932–33	15,230	
1934	9,486	
1935	59,406	
1936	44,391	
1937	308,994	
1938	456,884	
Total	$2,437,760	

**Note:* In this table, only those years have been quoted for which actual figures or reliable approximations could be obtained. The omission of a year from the table does not necessarily mean that there was no gold production that year, but merely indicates that no reliable statistics of production were available.

METAMORPHIC ROCKS

The metamorphic rocks of the district are divided into two distinct groups which occur in separate areas.

Vitrefrax Formation

This formation is named from its best developed exposure in the Bluebird quarry on Vitrefrax Hill (Plate II, No. 17). The formation covers only a very small area of the district, notably Vitrefrax Hill itself and Micatalc Hill to the north.

The Vitrefrax formation comprises several indefinitely bounded lithologic units. The lowermost of these units is white quartzite which grades into sericite schist or quartz-mica schist. Above this lies sericite schist, which in turn grades upward into kyanite-bearing quartz-sericite schist, thence into white kyanite-bearing quartzite, thence into sericite schist with abundant magnetic metacrysts, and finally into kyanite-bearing quartz-sericite schist. Texture is fine to medium grained for the most part, yet where the kyanite is best developed the crystals occur in large matted aggregates and in radiating groups several inches long.

The presence of strikingly different rock types in a limited area, the layered character of these rock types, and the close resemblance of the total composition of these rock types to that of silty sandstone, point toward the theory that the Vitrefrax metamorphics were derived from sediments. The quartzite and its variations were undoubtedly formed from sandstone. The talcy sericite layers were derived by metamorphism perhaps from dolomitic beds, although a basic igneous rock would be an equally adequate initial type. In the kyanite-bearing quartz-sericite schist, the completely random orientation of the kyanite crystals coupled with the vuggy nature of the sugary quartz matrix militates strongly against a regional dynamic metamorphic origin for the deposit. Hydrothermal solutions working on a more aluminous member of the series is suggested as the most likely agent in causing this metamorphism.[13] Ferruginous clay shales may have been the original material from which was produced the magnetite-sericite schist.

Evidence of later pneumatolytic action is also present in the area. About 900 feet directly south of Micatalc Hill, near a fault zone separating metamorphics from biotite granite, numerous euhedral black tourmaline crystals are disseminated through the kyanite-bearing quartz-sericite schists. The tourmaline also occurs in fine-grained veinlets cutting the schists. Accompanying the tourmaline is waxy green to white steatite, often filling the interstices of broken tourmaline needles. A small amount of pyrite is irregularly scattered through portions of the Vitrefrax formation.

In the same limited locality small dikes and veins of quartz-feldspar pegmatite containing specular hematite crosscut the tourmalinized and steatitized kyanite schist. One quartz vein containing a seam of specular hematite occurs undisturbed in a fault zone filled with talcy gouge.

Another group of metamorphic rocks may be included with the Vitrefrax formation. These outcrop on the extreme eastern border of the southern half of the range. The occurrence is very much confused by abundant aplitic intrusions in the form of small dikes and irregular plugs.

One horizon of these metamorphics outcrops discontinuously along ridge tops for over a quarter of a mile in a more or less straight line, striking N. 10° E. and dipping 50° SE. This ridge-forming rock varies from an extremely hard white quartzite, which occasionally bears epidote, to a rock bearing abundant wollastonite and occasional coarsely crystalline calcite. The outcrop has weathered to form a rough solution-pitted surface like a normal limestone under desert conditions. The rock probably originated from the metamorphism of a calcareous sandstone.

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[13] *Note:* The controversy concerning the origin of kyanite centers about the question of whether or not *new material* has been added to the country rock by the agency of hydrothermal solutions. A few of the classic and a number of more recent references on this subject are cited below.

Dunn, J. A. Andalusite in California and kyanite in North Carolina. Econ. Geol. vol. 28, no. 7, pp. 692-95. 1933.

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Vernadsky, W. Note sur l'influence de la haute temperature sur le disthene. Bull. Soc. Fr. Min. vol. 12, pp. 447-56. 1889.

Wallace, R. C. An unusual occurrence of cyanite. Amer. Min., vol. 9, pp. 129-135. 1924.

Wilson, E. D. An occurrence of dumortierite near Quartzite, Arizona. Amer. Min., vol. 14, pp. 373-81. 1929.

A fine- to medium-grained dense gray rock occurring nearby commonly displays laminae and bedding. It appears to be a strongly metamorphosed feldspathic sandstone.

A third variety consists of a fine-grained black biotite-hornblende schist. Although sometimes only slightly folded, this schist is often very strongly contorted, especially when it is near a contact or is in fairly large inclusions in quartz monzonite. The origin of this schist is uncertain. On the basis of lithologic similarity, this schist may be the source of inclusions in the quartz monzonite on the southeast side of the range.

Tumco Formation

This name is applied to the metamorphic terrane lying in the Tumco Valley and extending north and south therefrom for about a mile. A strip of this formation can be traced through the northern part of the range over to the east side where there lies another considerable area of metamorphosed sediments. With neither top nor bottom exposed, the minimum stratigraphic thickness of the formation is more than 6,000 feet.

Gray to pinkish-gray, highly indurated, massive, and closely to sparsely jointed arkosite is the type rock of the formation. In texture the rock is fine grained. It consists dominantly of quartz and feldspar with small amounts of hornblende and biotite. Minor variations in mineral composition and in grain size produce a slight effect of banding in the arkosite. The main joints parallel the bedding planes, while the next most important joints stand vertically and strike roughly north.

Under the microscope the rock is fine to medium grained. The principal minerals include feldspars, 50 percent (approximately equal amounts of orthoclase and microcline); quartz, 45 percent, rounded grains; biotite, 4 percent, large, strongly pleochroic grains often showing parallel alignment; and hornblende, a few medium-sized grains, pleochroic yellow-green to blue-green. Accessory minerals consist entirely of magnetite, apatite, and zircon.

The Tumco formation is not uniform in appearance. Most important of the variations are those due to differences in the original materials from which the rocks were formed, giving two main types, arkosite (described above) and hornblende schist.

The hornblende schist is a green-gray, schistose rock characterized by its thin-bedded nature and its large hornblende phenocrysts. It occurs in unjointed layers a few inches up to a foot thick at wide stratigraphic intervals throughout the arkosite series.

Microscopically this hornblende schist appears holocrystalline, with large crystals of hornblende and biotite scattered through a fine-grained feldspar and quartz groundmass. Feldspar varies from 20 percent medium-grained orthoclase in the one extreme, to 20 percent orthoclase and 20 percent medium-grained microcline in the other. Quartz, 45 percent, occurs in medium-sized grains often elongated parallel to the schistosity. In thin-section under the microscope with nicols crossed most of the quartz grains display wavy extinction. Hornblende, 5 percent, appears as characteristically large grains, pleochroic from yellow-green to blue-green and paralleling the schistosity. Biotite, exhibiting strong pleochroism, varies in amount from 18 to 2 percent inversely with the amount of microcline present. Epidote, 8 percent, occurring in small scattered crystals, is found persistently throughout the schist. Apatite and magnetite are the dominant accessory minerals.

In composition the typical arkosite does not differ much from an ordinary granite. The thin fissile hornblende layers interstratified with the arkosite, and the slight but regular textural and compositional banding of the arkosite appear to be indications of sedimentary origin. This stratigraphic banding has been made especially evident by small sill-like intrusions, where the rock has been folded.

The texture of the mineral grains of which the rock is composed points to sedimentary origin. Feldspars with their rounded to irregular grains may have been sedimentary grains slightly recrystallized by metamorphic forces. Well-rounded quartz grains, on the other hand, could be only detrital in origin, though they may have been slightly elongated and somewhat strained by metamorphic activity.

Thinness of its beds and extremely fine-grained nature of its matrix, suggest a tuffaceous origin for the hornblende schist. The subhedral hornblende and biotite crystals in this schist were probably formed by mild metamorphism.

North of Tumco Valley the formation is very abundantly cut by dikes and penetrated by lit-par-lit sills which are granitic to pegmatitic in character. Intrusions increase in abundance as the contact between arkosite and leucogranite is approached. The actual contact is a very indefinite zone in which hundreds of sills finger into the arkosite. On the map (Plate II) the contact is drawn to represent the locus at which sills predominate over arkosite in a ratio of approximately 60 percent to 40 percent.

In the contact area between Tumco arkosite and leucogranite a number of suggestive features have been noted.

Rocks with typical fine-grained texture of the arkosite can be traced along a single stratigraphic horizon until they have changed by a series of minute variations to completely granitoid leucogranite.

Coincident with gradual textural change is an equally gradual compositional change. Fine-grained gray to pinkish-gray feldspars in arkosite give way to light-gray and white feldspars in leucogranite. Biotite content which is quite high in some of the arkosite near the contact area, decreases considerably as gradual transition is made into leucogranite. Magnetite occurs in inverse proportions to biotite.

Likewise there is a gradual loss of sedimentary structure as the contact is traversed from arkosite into leucogranite. This loss of sedimentary structure occurs even more slowly than do the variations in texture and composition. Hence, in many cases where the rock is both texturally and compositionally leucogranite, it still bears evidence of structural similarity to stratified arkosite. This stratified appearance is caused by differences in mineralogy, texture, color, or hardness of different layers of leucogranite. Very commonly the small amount of biotite in the leucogranite is in parallel alignment with the regional structure of the arkosite. Weathering of the rock surface generally aids in accentuating the minor differences between layers and hence emphasizes the sedimentary appearance of this type of leucogranite.

Throughout the leucogranite are abundant arkosite inclusions. North of the leucogranite-arkosite contact, the inclusions decrease in number and in size, and are more completely digested. On the map (Plate II) a few of the largest inclusions are represented by attitude symbols placed within the leucogranite proper. All of the major inclusions are oriented parallel to the regional trend of the arkosite.

Two textural anomalies occur in the arkosite and in the granite of the contact area. It can be observed under the microscope that while type Tumco arkosite contains a considerable amount of microcline, this microcline occurs characteristically in small, somewhat rounded, slightly kaolinized grains. As the contact with the leucogranite is neared, however, large, irregular microcline crystals, many of which are considerably kaolinized, become increasingly abundant. This same relationship has been noted, but not so commonly, in the case of orthoclase.

In type leucogranite, most of the quartz is in small to moderate-sized angular to irregular-shaped grains. However, some quartz in the leucogranite, most notably in the contact area, consists of small, rounded grains, a few of which are actually included in large microcline and orthoclase crystals. These phenomena are evidence that the leucogranite was formed by the granitization of original arkosite in the area.

The textural change might have been brought about by an increase of temperature and pressure.

The compositional change is not important in terms of total composition. The reworking of the feldspars converted gray-tinted feldspars in arkosite into clear feldspars in leucogranite. It has been suggested[14] that the clouded gray effect of many feldspars is caused by the presence of dustlike inclusions of ferruginous material, chiefly hematite, or, less abundantly, magnetite. The segregation of this ferruginous material as well as partial breakdown of biotite and hornblende may account for the slightly greater amount of magnetite in the granite.

The gradual loss of sedimentary structure accompanies more complete digestion of the arkosite by the granitizing solutions.

The varying stages of digestion of the inclusions as well as their parallelism of orientation suggest infiltration and penetration by replacing solutions rather than forcible intrusion of a displacing magma.

The large feldspar crystals in the arkosite of the contact area are interpreted as metacrysts representing the first stages of granitization.

The quartz inclusions in the feldspars of the leucogranite are interpreted as being the last undigested remnants of the original arkosite.

IGNEOUS ROCKS

The igneous rocks of the district have been tentatively mapped as several types. A series of four major igneous intrusions make up the bulk of the range and extends almost continuously along the center of the range from south to north. The rocks vary from an extremely dark quartz diorite in the south to an almost white granite in the north. They seem to be a related sequence of successive intrusions into the metamorphic terrane.

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[14] Anderson, G. H. Granitization, albitization, and related phenomena in the northern Inyo Range of California-Nevada. Bull. G. S. A., vol. 48, pp. 1-74, 10 pls., 11 figs. 1937.

Quartz Diorite

Quartz diorite occurs in the southern part of the range in a belt lying to the south of the Madre Valley, extending eastward to Jackson Gulch and thence northward to Obregon Valley.

The rock is dark in appearance, containing abundant biotite and hornblende. The quartz and feldspar are gray. Texture is generally granitic, though locally it becomes gneissoid.

Microscopically the rock is holocrystalline and fine to medium grained. Andesine (An 45) makes up 25 percent of the rock. Orthoclase, 5 percent, is present in the form of large, highly kaolinized crystals. Quartz occurs to the extent of 20 percent in fairly well-preserved grains interstitial to the feldspars. Biotite in strongly pleochroic euhedral crystals forms 20 percent of the rock. Hornblende, likewise 20 percent, occurs as strongly pleochroic yellow to dark-green crystals, partly resorbed by later quartz grains. Epidote, 8 percent, is formed as small euhedral crystals scattered in the feldspars. Accessory minerals include apatite, zircon, and occasionally magnetite.

In its northeastward extension the diorite bears numerous dark schistose inclusions. Many of these inclusions contain abundant microscopic hairs of sillimanite.

Quartz Monzonite

Quartz monzonite makes up the whole eastern portion of the southern half of the range, as well as the hills to the south of the range. This quartz monzonite may eventually be mapped as two or three rock types, for its mineral content varies considerably.

It is characterized megascopically by grains and aggregates of dark biotite and hornblende sharply contrasting with light-colored feldspar and quartz. The texture of this rock is typically granitoid, but in a number of isolated spots it is gneissic, having been subjected either to primary flowage or to secondary localized shearing or compression.

Upon examination under the microscope, the quartz monzonite appears holocrystalline, subequigranular, and granitoid in texture. Feldspar comprises about 55 percent of the rock. Of this, 10 percent is orthoclase, and 20 percent microcline; the remaining 25 percent consists of andesine (An 45). Twenty percent of the rock is quartz, mostly in small grains. Euhedral, strongly pleochroic biotite makes up 18 percent of the rock. Other minerals include hornblende together with the accessory minerals apatite, magnetite, and zircon. Sericite occurs as an alteration of the feldspars. Epidote, which may attain considerable proportions locally, is found both in veins and as disseminations.

In its less typical phases, the quartz monzonite may become either aplitic or porphyritic in texture. The porphyritic phase contains large orthoclase phenocrysts in the form of Carlsbad twins up to 4 inches long. This porphyritic type occurs in small dikes, 1 to 15 feet wide, cutting the main body of the quartz monzonite. While the adjacent normal quartz monzonite bears abundant dark inclusions, the porphyritic facies bears none.

Biotite Granite

This rock occupies the southeastern quarter of the northern half of the range. It varies somewhat in appearance. A closely related rock type outcrops in the area immediately to the south of the American Girl mine. Scattered stocks of biotite granite intrude the quartz diorite on the south edge of Obregon Valley.

Megascopically this rock is characterized by the abundant occurrence of coarse pink to gray feldspar as well as by the presence of biotite as the major dark mineral.

Under the microscope the composition of a typical specimen is seen to be 50 percent orthoclase and microcline, 40 percent quartz, 8 percent biotite, and a little hornblende. Accessory minerals include zircon, magnetite, and a few grains of apatite and garnet. The texture of the rock appears characteristically holocrystalline, fine to coarse grained. The large feldspars are believed to be metacrysts, and much of the quartz occurs as small rounded grains. The presence of these small rounded quartz grains scattered throughout the rock strongly suggests that the biotite granite in its present form was derived from a quartzitic sediment by granitization.

Between the American Girl mine and Micatalc Hill the rock has been so thoroughly altered that it has assumed a dense greenish-black appearance relieved only by scattered feldspar metacrysts. The rock contains orthoclase, 20 percent, in large pink Carlsbad twins, quartz, 50 percent, in small subrounded grains, biotite 18 percent, hornblende 5 percent, and epidote 8 percent. Accessory minerals are apatite and zircon.

Leucogranite

The whole northernmost part of the range and the northeastern portion of the outlying hills to the northeast of the range are composed of granite. Several small granite stocks were observed in the eastern portion of the southern half of the range. This granite contains few dark minerals. Its texture varies from even-grained granitoid to gneissic.

A typical specimen contains about 52 percent feldspar, of which 30 percent is orthoclase in irregular, slightly kaolinized grains, 20 percent is microcline, and 2 percent is oligoclase. The latter are also in small irregular grains. Quartz as subrounded grains, suggestive of sedimentary origin, makes up 47 percent of the rock. Highly pleochroic and partially resorbed biotite crystals are present and show a slight tendency towards alignment. Accessory minerals include apatite, zircon, and magnetite.

Closely associated with the granite, and often obviously emanating from it, are numerous pegmatitic and aplitic sills and dikes. These are composed of 98 percent quartz and feldspar, with small, red garnets making up the remainder. Often hand specimens of the dike and sill rock cannot be distinguished from the leucogranite.

Origin of the Granitoid Igneous Rocks

The igneous rocks discussed in the preceding pages have many characteristics in common. Only broad types were distinguished in mapping, though more detailed study would certainly justify further subdivision of some of these types. In the field the leucogranite and less commonly the biotite granite are locally characterized by an alignment of minerals and a bedded appearance which are not found in the quartz monzonite and quartz diorite.

From field evidence the quartz diorite seems to be the oldest of the intrusives. Its relationship to the older metamorphics can be demonstrated at only a very few localities. On the east end of Micatalc Hill the diorite intrusive contact cuts across the schistosity of the earlier Vitrefrax formation. To the south and west of Kyanite Hill another contact between these two formations can be seen. At this latter locality, however, the alluvium-mantled outcrops are not continuous enough to give a clear-cut picture of the relationships.

At the east end of Madre Valley and again in the area just north of Jackson Gulch, the intrusive relationships between the quartz diorite and the younger quartz monzonite are well displayed. Narrow stringers of quartz monzonite penetrate the quartz diorite. At the same place, the quartz monzonite contains abundant xenoliths of quartz diorite.

The dike-like bodies of porphyritic quartz monzonite and aplitic quartz monzonite which occur in the southeastern portion of the range cut the main body of the quartz monzonite with many stringers and apophyses. Accordingly these minor facies are younger than the rest of the quartz monzonite. Their relationships to each other and to any of the supposedly subsequent rocks are unknown. Similarity of composition provides the only reason for supposing that these dikes intruded immediately after rather than long after the emplacement of the main body of quartz monzonite.

The mode of intrusion of the biotite granite differed from that of the earlier intrusions in that replacement rather than displacement of the country rock began to assume an important role. These relationships may be observed best at the eastern end of Tumco Valley. There the biotite granite definitely cuts across the earlier Tumco arkosite. At the same time, however, especially in its alignment of minerals, the biotite granite contains hints of structural parallelism with the arkosite. On the other hand, the small stock-like masses of biotite granite in the southern part of the range show no structural parallelism whatsoever. These latter masses undoubtedly displaced or stoped out the preexisting country rock.

Subsequent to the emplacement of the biotite granite, the leucogranite intruded the northern part of the area. A number of textural and structural features, which can be observed in the leucogranite, suggest that this igneous rock granitized or replaced rather than displaced the Tumco arkosite.

Along with the intrusion of the leucogranite, the entire area, especially in the north, was shot through with aplitic and pegmatitic sills and dikes. These relationships can best be seen on the west side of the mountains about a mile north of Tumco Valley.

Andesite

Andesite may be observed in a number of outcrops too small to map in and along the western border of the biotite granite north of Obregon Valley, and in a single large dike-like outcrop on the west end and skirting the north side of Micatalc Hill. The rock is extremely fine grained, appearing almost aphanitic. The matrix is a compact mass of very fine needles and laths. A peculiar feature about this andesite is the scattered occurrence of angular to well-rounded pebble-like fragments of milky white quartz. These fragments are generally small, but may at times be 2 inches long. Occasional aggregates of biotite occur in the rock. Fresh andesite appears greenish gray and dense. It weathers to a pale earthy brown. It shows no indications of metamorphism.

Under the microscope the andesite is fine to medium grained and has an andesitic groundmass. Tabular and lath-shaped crystals of andesine are most common, 50 percent. Quartz, 2 percent, occurs as small granular inclusions. Biotite, 30 percent, is found in patches of strongly pleochroic grains. Augite, 8 percent, develops as large, euhedral, almost colorless phenocrysts. Magnetite 2 percent, hornblende 1 percent, and glassy groundmass 7 percent, make up the rest of the rock.

Olivine Basalt

Olivine basalt caps three hills within the area mapped. All are small hills set apart from the main range. One hill lies at the east end of Obregon Valley; the second at the west end of the same valley; and the third is located on the west end of the hills to the south of the range. The cap varies in thickness from about 75 feet on the round-topped hill east of the mountains, down to nothing where it wedges out in the southern hills. The facts that scattered basaltic debris is to be found in the alluvium all over the district, and that just outside the area there are several other hills which are capped similarly to those here described, testify to the former magnitude of areal extent of these flows. The writer suggests that they may at one time have been continuous with flows which cover the Chocolate Range from 12 to 20 miles to the east and north. At least there is no evidence of any nearer source.

The basalt is fine grained and highly vesicular near both top and bottom of the flows. No structures were encountered which would afford evidence of direction of flow. The basalt is dark gray in color and bears a scattering of brownish crystals of olivine. Under the microscope the rock is seen to be holocrystalline and basaltic in texture. Laths of labradorite make up 60 percent of the rock, olivine in large euhedral crystals 12 percent, augite in small crystals 25 percent and magnetite 2 percent.

ALLUVIUM

In the area mapped there are present at least three ages of alluvium. The oldest type has been observed in only one locality. This is a high ridge consisting solely of alluvial material and lying about a quarter of a mile northwest of the lava-capped, round-topped hill to the east of the mountains. Poorly sorted, angular, or only slightly rounded pebbles and boulders characterize the material. Although occasional boulders attain a size of 2 or 3 feet across, most of the material ranges from 1 to 6 inches in diameter. The fragments are heterogeneous in character, the bulk (about 80 percent) are of the schist, while the remainder are mostly of quartz and granite. Some of the large boulders consist of dense, fine grained dumortierite,[15] others are of kyanite schist, while in a few boulders kyanite is found in conjunction with dumortierite.

Because of the great size of the boulders involved, and because of the angular to subrounded character of the material, this oldest alluvium appears to have suffered but little transportation. On the other hand, this alluvium has an abnormally high content of schist boulders for which no apparent local source exists. For example, the presence of dumortierite-bearing boulders, some of which are identical with those described by Wolff[16] from 10 miles north of the Cargo Muchacho Mountains, places the boulder source possibly that far away. According to O. R. Grawe[17] the Imperial County dumortierite appears to have had a common origin with the boulders from Clip, Arizona. (The town of Clip was located more than 30 miles to the north of the Cargo Muchacho Mountains near the present camp of Cibola, Arizona.) If there was a common source for all of these boulder deposits of dumortierite and dumortierite with kyanite, it remains unknown. The agent which distributed them was probably the Colorado River flowing in a long-since-abandoned course which led across the area now occupied by the Chocolate and Cargo Muchacho Mountains. On the other hand, there may have been several independent local sources which have been eroded away or covered by alluvium.

A second type of alluvium consists dominantly of ellipsoidal pebbles, extremely well waterworn and well sorted. This alluvium lies on the flat area to the east of the mountains and in long alluvial ridges between the washes south of the southeastern part of the range. Where it occurs near the older schist-bearing alluvium this pebble alluvium forms terraces which overlap the older type. The ellipsoidal pebbles are very constant in their composition, almost all being of chalcedony or jasper, but a few being of flint and quartz. One chert pebble was found which bore the impression of a large crinoidal stem. This material is certainly not local in origin because: (1) there exists no local source for such material, and (2) the material must have been transported far to be so well polished and sorted. It is believed that this alluvium, likewise, was deposited by the Colorado River when it was flowing on a now-abandoned course. In their early explorations in the region both Blake[18] and Newberry[19] noted this pebble alluvium. Each assigned a Carboniferous age to the source rock. J. S. Newberry says the fossiliferous pebbles "derived, as I subsequently ascertained, from the Carboniferous limestone many miles above."

A third type of alluvium is the Recent slabby, angular, locally derived material which covers most of the fan area around the Cargo Muchacho Mountains. To the south of the mountains this alluvium can be seen overlying the rounded-pebble type of alluvium.

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[15] Mackay School of Mines Staff. Dumortierite. Univ. of Nevada Bull., vol. 22, no. 2. 1928.

[16] Wolff. *op. cit.* 1930.

[17] Mackay School of Mines. *op. cit.* 1928.

[18] Blake, Wm. P. Geological Report (Williamson's reconnaisance in California) U. S. Pacific R. R. Expl. vol. 5, pp. 112, 117-118, 230-232. 1856.

[19] Newberry, J. S. Report upon the Colorado River of the west, by Lt. Joseph C. Ives, Washington, D. C. 1861.

ILLUSTRATIONS ACCOMPANYING REPORT

By Paul C. Henshaw

CARGO MUCHACHO MOUNTAINS

Figures 1 to 15

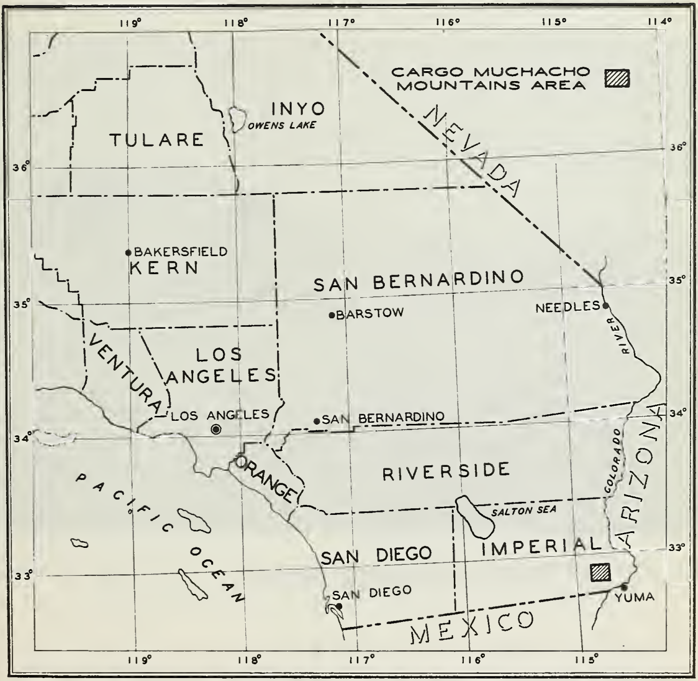

FIG. 1. Index map showing location of Cargo Muchacho Mountains.

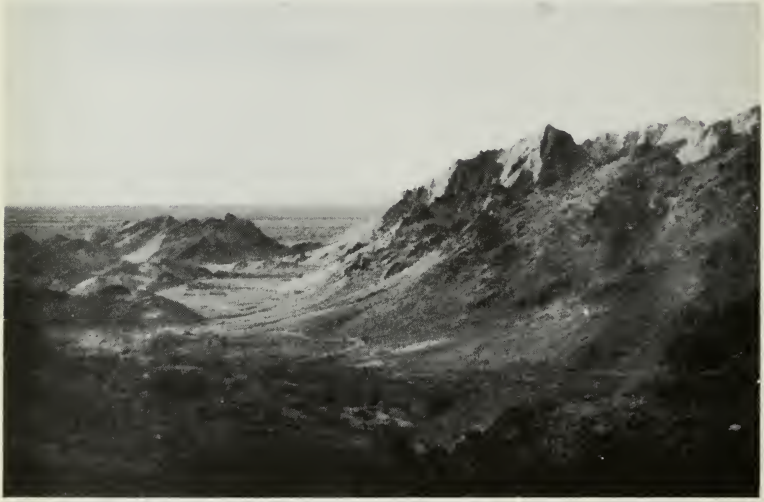

FIG. 2. View northwest from Coffee Pot prospect. On the left the silled Tumco formation can be seen dipping to the southwest.

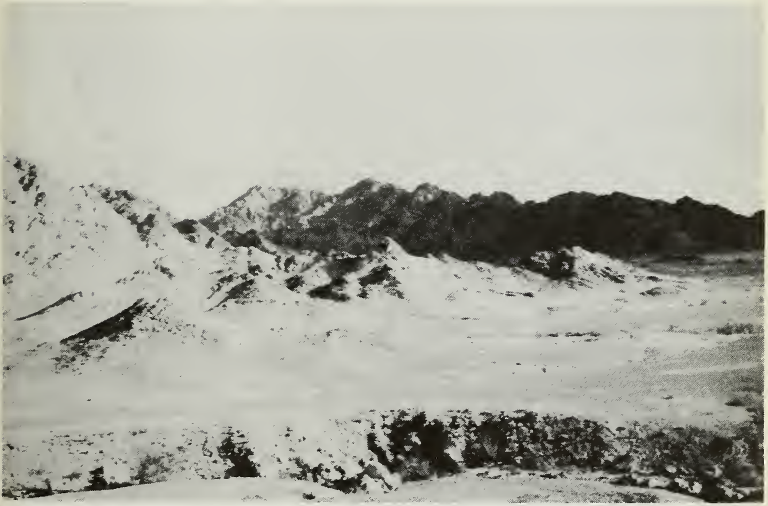

FIG. 3. View southeast from the northwest corner of the area mapped. Tumco formation in right centerground dips away from leucogranite in left centerground.

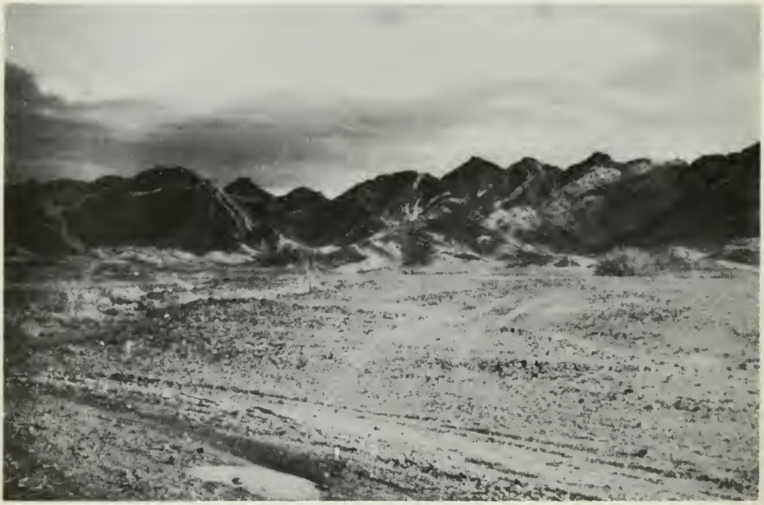

FIG. 4. Pegmatite dikes in the Tumco formation. View northeast from a point near the lava-capped hill at the west end of Obregon Valley.

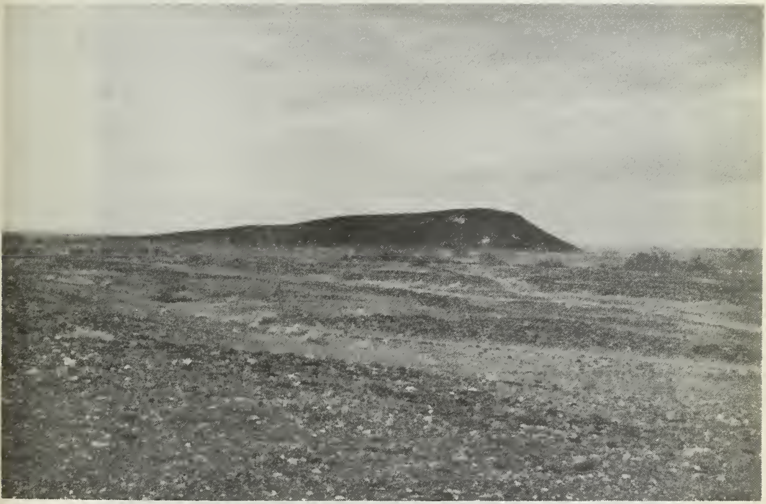

FIG. 5. Lava-capped hill at the west end of Obregon Valley. View northwest.

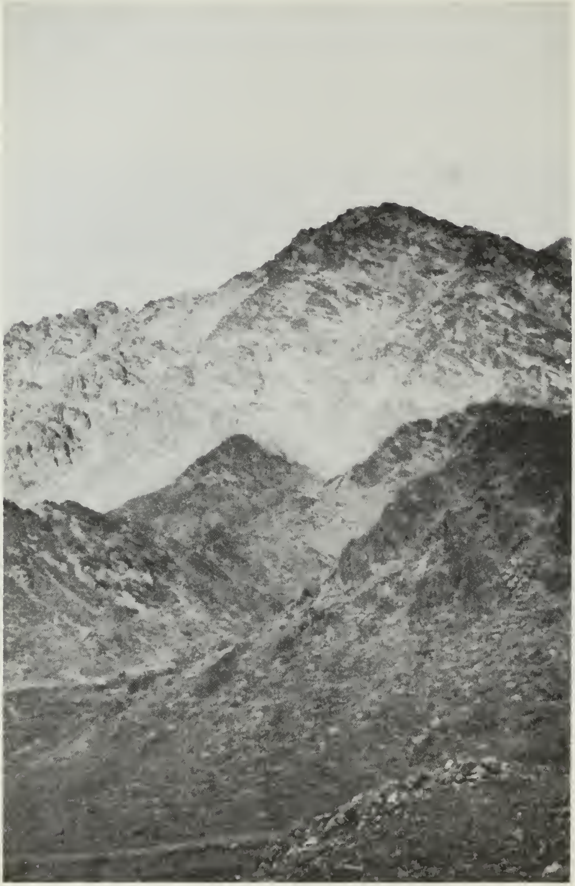

FIG. 6. Tumco formation containing abundant pegmatitic sills. View northeast from Coffee Pot prospect.

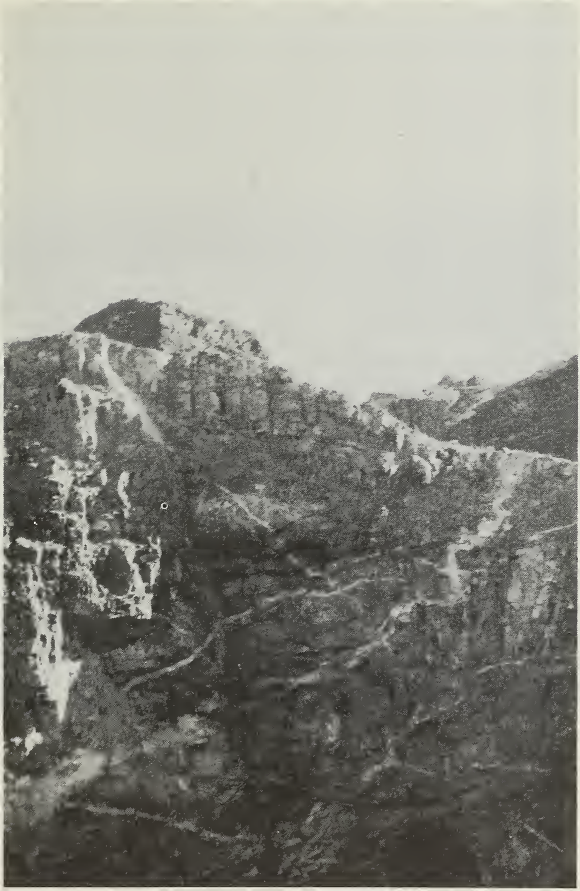

FIG. 7. Pegmatitic veins in the arkosite of the hanging wall, Golden Queen mine, Tumco Valley.

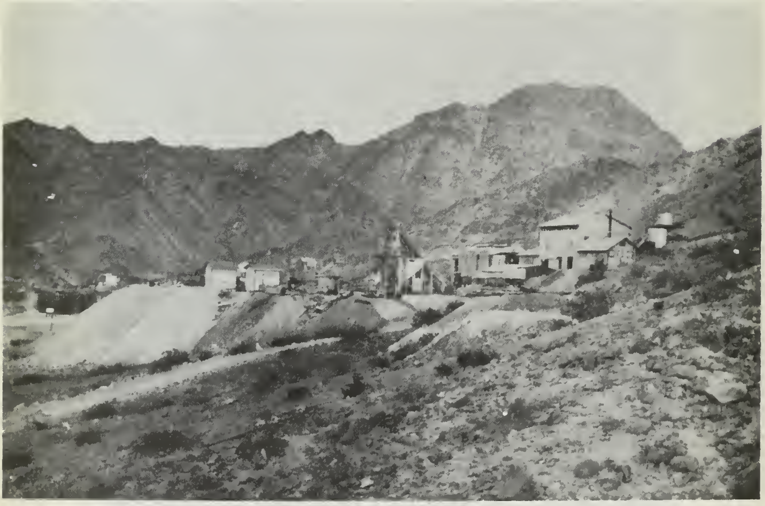

FIG. 8. Tybo shaft of the American Girl mine. Pasadena Peak in the background.

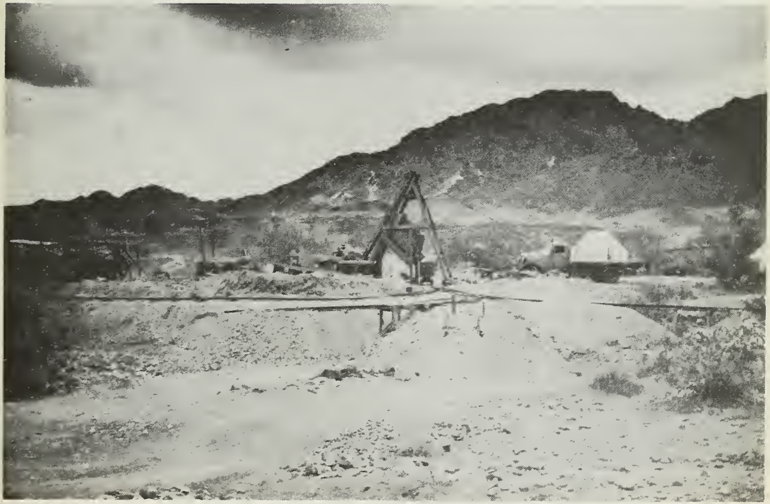

FIG. 9. Valencia shaft of the Blossom mine.

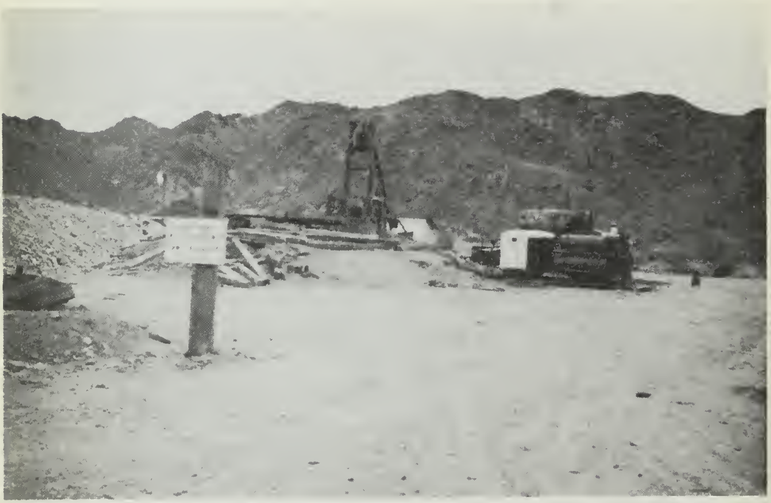

FIG. 10. Madre Number Two shaft.

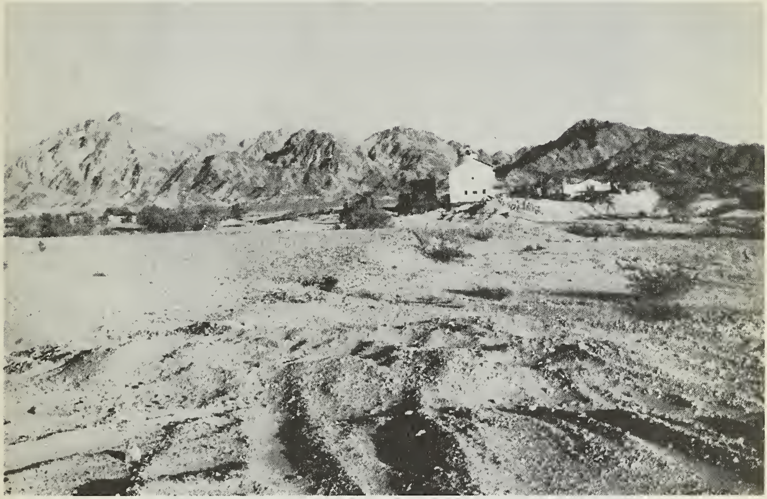

FIG. 11. Sovereign mill from the west.

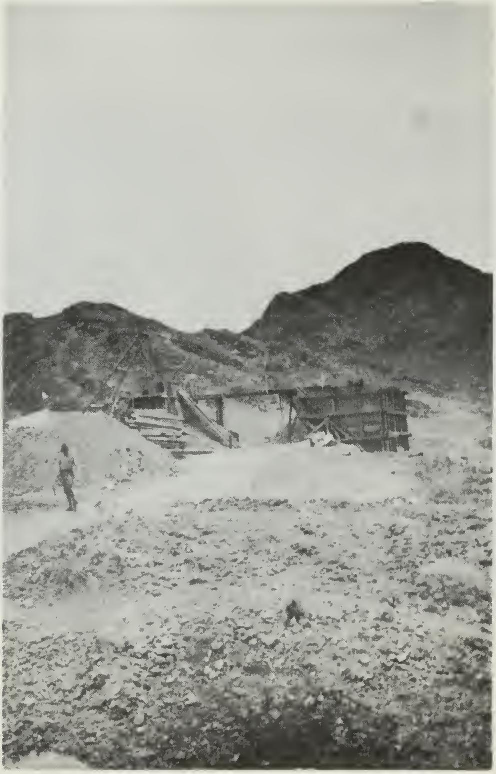

FIG. 12. Madre Number One shaft.

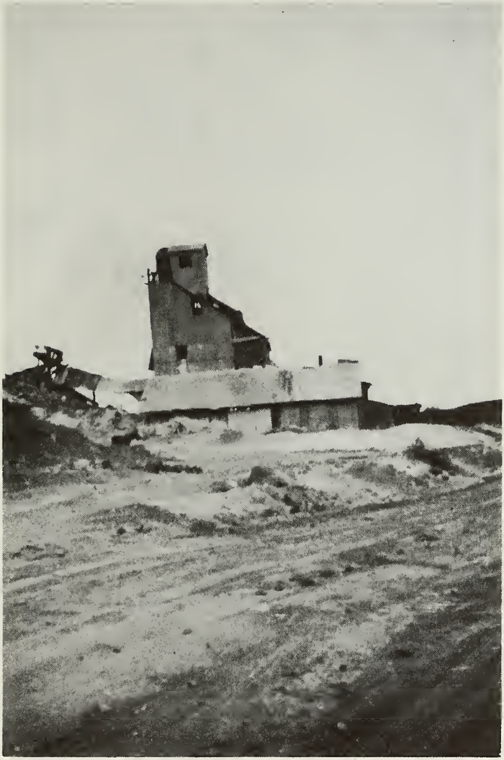

FIG. 13. Micatalc mill.

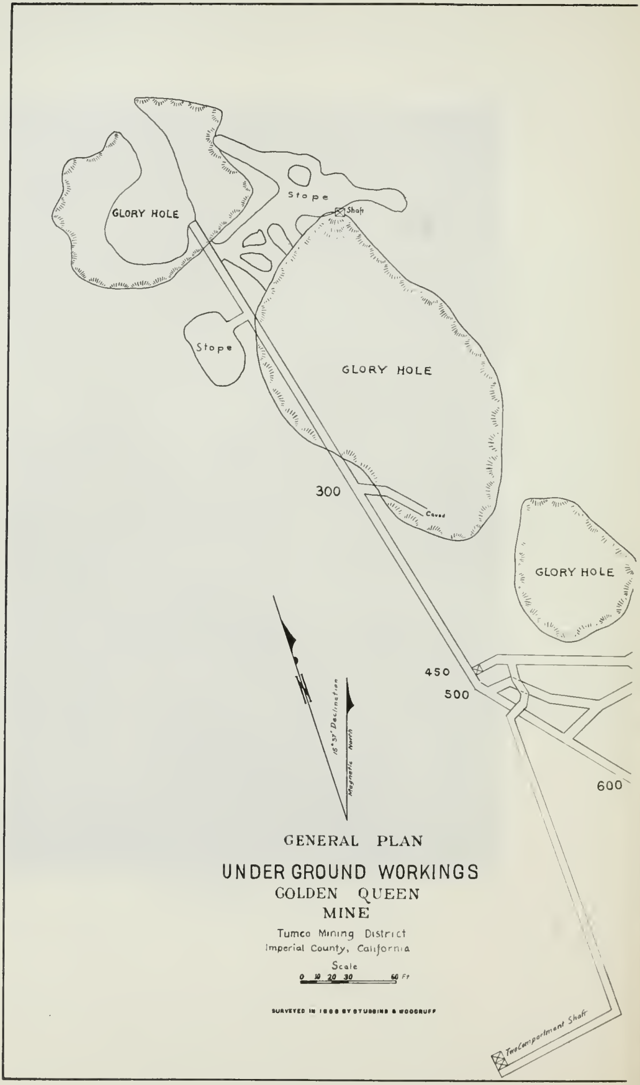

FIG. 14. General plan, underground workings, Golden Queen mine.

(Completed on next page)

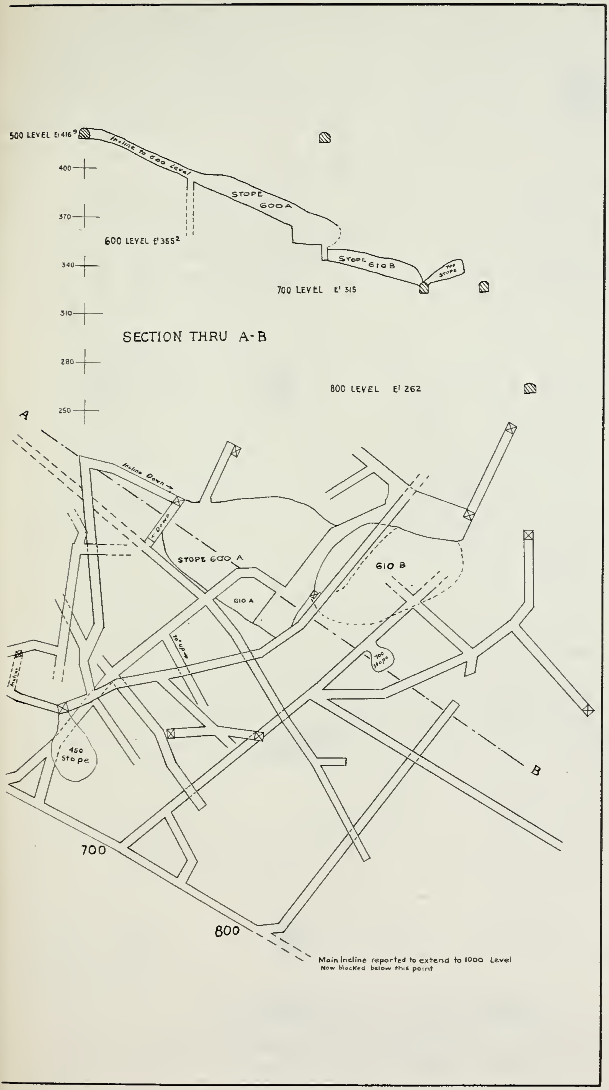

FIG. 14. General plan, underground workings, Golden Queen mine.

(Continued from preceding page)

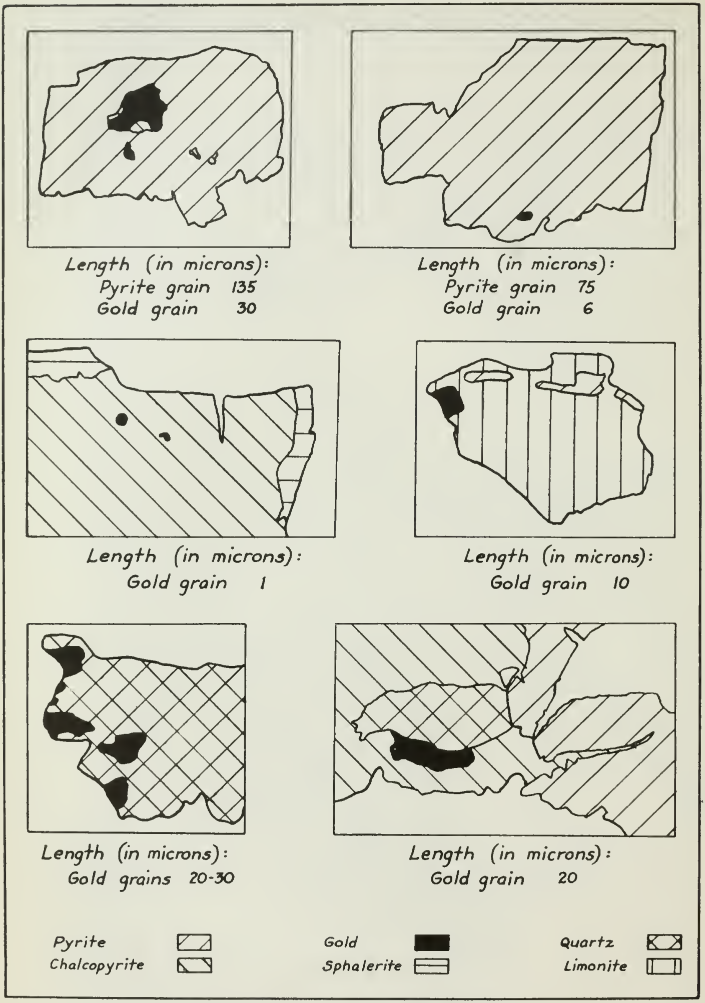

FIG. 15. AMERICAN GIRL MINE CONCENTRATES

Drawn from photomicrographs of polished sections.
American Cyanamid Company report.

STRUCTURAL GEOLOGY

Subsequent to the emplacement of the intrusions described above, faults played the dominant role in the development of the structure of the Cargo Muchacho Mountains. Faults are numerous and fault blocks are characteristic structural units. Folding, on the other hand, was of only slight significance in the structural history of the range.

INTRUSIONS

The earlier igneous intrusions in the range exhibit the characteristic features of typical stocks. The intrusive bodies have partly folded and partly cut across the country rocks. So far as could be determined the intrusions have steeply inclined, relatively smooth walls, and no floor visible. Localities where inclusions are more abundant than the intrusive represent roof and border phases where the invading magma was commencing to stope the country rock.

The intrusion of the leucogranite exhibits clearly some features which are commonly observed in connection with stock-like intrusions and others which are commonly associated with replacements. In the first place, the metamorphic rocks are intruded by the granite and dip away from the supposed center of intrusion (Figs. 2, 3).

Secondly, within the leucogranite are a great many actual inclusions of the metamorphics. Far more abundant than actual inclusions are the relic structures of the Tumco arkosite within the leucogranite (discussed above). In every case these inclusions and relic structures maintain the regional dip of the invaded Tumco arkosite. That is, the country rock was not displaced, beyond perhaps a regional up-bowing, centering on a point to the northeast of the northern end of the range.

Thirdly, associated with the intrusion are a tremendous number of sills which are remarkably persistent (Fig. 6). These sills range from a few inches up to 8 or 10 feet in thickness. Those which are 2 or 3 feet thick are most common. Above and below some of these sills which lie to the southwest of the granite, the metamorphics have been deformed by little drag folds which are of such a nature as to indicate intrusion coming from the southwest at depth and traveling in a northeastwardly direction, or toward the center of the granite outcrop.

Among the minor intrusive features is the lenticular appearance of some of the sills in the metamorphics. In this case, the metamorphics obviously have been displaced and not replaced, for the layers of the Tumco arkosite can be seen to pinch and swell as they lap around the lenses of pegmatitic sills. Upon examination of detached blocks of rock containing these sills it can be shown that the pinches in the sills are localized points, not ridges or waves. That is, in three dimensions the sill is ''tufted,'' like a quilt formed by pinching only single points together.

A fourth feature of importance is the vast number of dikes, both granitic and pegmatitic, which occur in the northern part of the range and which are probably connected very closely with the origin of the sills and granitic stock itself. These dikes do not appear as systematic swarms, but crisscross the country in every direction (Fig. 4). For the most part they are steep-dipping to vertical. The facts (1) that the dike rock is often indistinguishable in composition and texture from the leucogranite, (2) that the dikes become increasingly abundant as the leucogranite is neared, and (3) that no dikes have been found cutting the leucogranite itself, are interpreted as evidence that the source of the dike material was the leucogranite.

Another minor feature is the abundant ptygmatoid folding of very small dikes, usually less than an inch thick. Such dikes, though occurring in relatively unfolded rocks, are highly irregular in all three dimensions, and are probably a replacement phenomenon rather than the result of open space filling.

All of these features emphasize the facts that the topography cuts the very top of the granitic intrusion and near the tops of the older intrusions, and that the features here exposed might be termed acrobatholithic.[20]

The structure of the outlying hills on the northeast of the range precisely duplicate the acrobatholithic structure of the north end of the range. Hence, instead of being a separate but contemporaneous intrusion, the rocks in these hills may constitute a down-faulted extension of the same structure which dominates the northern end of the mountain mass.

FOLDS

In the metamorphic rocks of the Cargo Muchacho Mountains folding does not rank as a prominent structural feature. In fact, there is but a single major fold in the whole range, namely the broad warp which the Tumco arkosite makes as it dips off to the west and south away from the granite intrusive in the north (Figs. 2, 3). There a swing from a strike of N. 45° W. to a strike N. 45° E. is spread out over 2 miles.

Small drag folds have been noted in the Obregon Valley, as well as at numerous points underground in the American Girl mine. The largest one observed in the mine involved a shortening of only 2 or 3 feet, while the largest seen in the field might have caused a shortening of about 30 feet. The significance of these drag folds will be pointed out under the discussion of faults.

FAULTS

Thrust faults mark most of the major eastward trending valleys in the area. These faults are best observed and traced in mine entries and prospect pits. At least four such thrusts are known in Tumco Valley; one is known in Obregon Valley; and two are believed to occur in the Madre Valley. Undoubtedly more exist, perhaps some in the northern part of the range and perhaps others in the valleys already cited. The faults strike mainly between E. and N. 60° E., though local variations swing far outside of these limits. Likewise, dips are relatively limited, ranging between 20 and 40 degrees south. It cannot be proven that the movement on all these faults has been in the nature of a thrust. However, drag folds in the American Girl mine and small faults and drags observed in the walls of the Golden Cross glory-hole in conjunction with a low-angle fault of major proportions are indisputable evidence of thrusting.

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[20] Emmons, W. H. Metalliferous lode systems and igneous intrusives. TAIME, vol. 74, pp. 29-70. 1926.

Among the many northward-trending faults there are at least two of major importance. The greatest of these appears as a broad vertical gouge zone striking west of north, which lies along the northeast side of the main mountain mass.

The other important fault of this type lies immediately to the west of Pasadena Peak and may readily be traced in the valleys and notches. It strikes about N. 35° E. and appears to be vertical. It is characterized by a shattered zone 10 to 20 feet wide which has been subsequently mineralized. The dominant minerals in the fault zone are epidote, brown calcite, silica, malachite, and limonite. On the northwest side, the rock is all biotite granite, while that on the southeast is quartz diorite, bearing very dark inclusions. Farther down the valley to the southwest, the fault zone ceases to mark the contact between these two rock types. Likewise, to the northeast the contact swings away from this fault. Thus the fault has displaced the igneous contact between the biotite granite and the quartz diorite, locally making a fault contact between the two.

From areal relationships the fault is considered of the strike-slip variety, the west side having moved northwestward offsetting the intrusive contact between the biotite granite and quartz diorite. If this hypothesis is correct, a slip of more than 2,000 feet is indicated. The implications involved in such a fault have a direct bearing on the problems connected with the American Girl mine, for the block which was moved northward is the hanging-wall block of the mine.

JOINTS

Joints in the region have reached far greater development in the igneous rocks than in the metamorphics. No single jointing system prevails over any great area. Three jointing systems appear to be more prominent than any others: (1) parallel to the range and steeply dipping, (2) transverse to the range and steeply dipping, and (3) variable strike and very shallow dip, giving a bedded sedimentary appearance to the rocks where best developed.

BASIN-RANGE STRUCTURE

To consider the possibility that the mountains owe their elevation to differential erosion would be to bring up the whole question of the origin and structure of the Basin and Range physiographic province. Without entering into this controversy the author merely states his belief that the role of differential weathering as a cause of the relative elevation of the Cargo Muchacho Mountains is negligible. Hence, some other cause must be sought.

Since within the range faults are prominent and folding is subordinate, it is probable that the mountains owe their present elevation to faulting. Though no means are at hand to prove this assumption, the range is thought to be a raised ''slice'' between two major faults, perhaps of the strike-slip variety. Such an hypothesis would make the Cargo Muchacho Mountains similar in origin to the Mecca and Indio Hills which lie to the northwest, on the east side of the Salton Basin.

PHYSIOGRAPHY

The processes and the land forms produced by weathering and erosion under arid conditions have been analyzed in detail by Lawson, Bryan, and others.

Approximately a mile to the south of the range lies a compact group of hills which are completely traversed by valleys draining to the south. In a similar manner, at least one small valley cuts northeastward through the lower hills which lie to the northeast of the main range. These valleys must have been either superimposed or antecedent. Coupled with this phenomenon is the fact that in the southern portion of the range the valleys which drain to the north may be observed to be long, of gentle gradient, and relatively open in contrast to the short precipitous steep-walled canyons draining southward. Furthermore, the older types of alluvium stand as much as 75 feet above the present alluvial surface. Overlying this older alluvium are remnants of what may once have been a single flow of basalt.

All of these facts may be coordinated by hypothesizing that the streams flowing away from the range gained their courses on a cover surface of old alluvium or perhaps even on the basalt, and maintained these same courses as the subjacent rock was exposed.

GEOLOGIC AGE AND CORRELATION

No means are at hand for determining the exact geologic age of the rocks of the Cargo Muchacho district. The lithologic units are similar in nature to the rocks of adjacent areas which have been described, *e.g.*, Eagle Mountains, California, 80 miles to the northwest,[21] various mountains of southern Yuma County, Arizona,[22] Tinajas Altas, Tule, and O'Neil ranges[23] 50 miles and more to the southeast, and S. H. or Kofa Mountains[24] 60 miles to the northeast.

In each case the author cited admits that his dating of the rocks is based upon similarity of rock type and degree of metamorphism to corresponding features in rocks of known date of other areas. In no case was it possible to date by paleontological evidence or by direct continuity of outcrop.

The same lack of adequate evidence as to geologic age prevails in the Cargo Muchacho district. Accordingly the following tabulation of geological events is accompanied by hypothetical age assignments.

GEOLOGIC HISTORY

1. A great thickness of quartz sandstone and arkosic sandstone was deposited, either preceded or followed by the formation of limestone beds and silty quartz sandstone strata. Probably pre-Mesozoic.
2. A series of granitoid rocks intruded the area, commencing with quartz diorite in the south and terminating with leucogranite, aplite, and pegmatite in the north. Probably Mesozoic.

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[21] Harder, E. C. Iron-ore deposits of the Eagle Mountains, California. U. S. Geological Survey Bull. 503. 1912.

[22] Wilson, Eldred D. Geology and mineral deposits of southern Yuma County, Arizona. Univ. of Ariz., Ariz. Bur. of Mines Bull. 134. 1933.

[23] Bryan, Kirk. The Papago Country, Arizona. U. S. Geological Survey, Water Supply Paper 499, pp. 58-59. 1925.

[24] Jones, E. L., Jr. A reconnaissance in the Kofa Mountains, Arizona. U. S. Geological Survey Bull. 620, p. 155. 1915.

3. Hydrothermal solutions accompanying the intrusions recrystallized the sediments, locally developing metamorphic minerals.
4. Shortly after the intrusion, the area was faulted by thrusts from the south. Solutions rose along the faults and mineralized part of the area.
5. Minor andesitic intrusion. Probably Tertiary.
6. Erosion almost to the present stage.
7. Deposition of old coarse boulder alluvium.
8. Deposition of fine rounded jasper and quartzite pebble alluvium.
9. Basalt flow. Probably Quaternary.
10. Erosion to the present stage and development of outwash alluvial deposits.

ECONOMIC GEOLOGY—METALS

GENERAL CHARACTER OF RESOURCES

Gold is the most important single resource of the region. In the past several large gold mines have been worked. At present all activity is restricted to a number of small-scale operations. Copper was produced along with the gold at the American Girl mine. Other mineral products of the district are sericite and kyanite.

STRUCTURE OF THE GOLD VEINS AND LODES

The gold deposits of the Cargo Muchacho district are all confined to the western side of the range. Although some mines are located in the far north and others in the far south, those in the Tumco Valley region have been most productive. All of the lodes have certain characteristics in common. They are all tabular bodies, usually associated with a definite footwall or a definite hanging wall, but rarely with both. All but three of the lodes trend east and west, parallel to the major thrust faults of the area. Locally, of course, strikes widely at variance with this may be found. Dips of the lodes are fairly limited in their scope. With extremes at 16°S. and 52°S., most of them lie between 20°S. and 40°S. The three major lodes which do not trend eastward are the easternmost mines of the district, the Pasadena, Guadaloupe, and Cargo Muchacho. They all trend roughly east of north and dip steeply to the east, parallel to some of the major north-trending faults of the area. Ore zones have been traced for considerable distance along the strike. Though the values may pass below an economic mining limit the structure continues. The same is true in following the ore at depth. Hence, the structure at any rate may be regarded as persistent.

The influence of fracturing on ore deposition is very important. Equally noteworthy is the close relationship between fracturing and rock type. Where a major fault traverses granite or quartz monzonite, the rock remains unfractured. On the other hand, a major fault in the metamorphic rocks or in quartz diorite shatters the rock. Though numerous prospects and even mines have been started on promising veins in the granite and in the quartz monzonite, none of these has ever proved valuable. Every mine in the district which has produced or is now producing gold on an economic basis occurs in metamorphics or quartz diorite. This influence of fractured country rock is brought out strikingly in the case of the Cargo Muchacho mine, in which the vein was exceedingly rich wherever it lay in quartz diorite. Where the structure passed southeastward into the quartz monzonite, however, the values disappeared.

A low-angle fault, whether it be hanging wall or footwall, generally forms one limit to the ore. The other limit is usually determined by assay rather than by any structural feature. Nevertheless, the values seem to be concentrated in a definitely bounded zone. These zones are abundantly fractured, although often the fractures are microscopic. The amount of ore occurring as fissure filling is negligible. Almost all of the ore appears to have been deposited by replacement, although, of course, the ore-bearing solutions entered along definite fracture channels.

ORE SHOOTS

In most of the mines in the district the ore shoots appear to trend roughly northward, or northeastward as in the case of the American Girl mine. The shoots are broadly related to zones of approximately northward-trending fractures.

ORES

Two main types of ore are known from the Cargo Muchacho district. In the more common and more extensively worked, the gold is free milling. In the second and less common type, the gold is included in disseminated pyrite.

COMPOSITION AND VALUE

Gold (and its included silver) and copper are the only minerals extracted from the Cargo Muchacho district ores. In the mines from which free milling gold is obtained the values run from $15.00 to $150.00 per ton. The gold content of the sulfide ores, on the other hand, averages only $5.00 to $20.00 per ton. The copper content in this sulfide ore normally more than pays for freight and smelting charges on the concentrate.

MINERALIZATION

Mineralogy

Mineral species which occur, or are associated with, the metallic ore deposits of the Cargo Muchacho district are listed below. Brief mention of their occurrence is also given:

Gold: native gold

Silver: native silver

Copper: chalcopyrite
    covellite
    chalcocite
    malachite
    azurite
    chrysocolla
    cuprite
    native copper

Iron: pyrite
    magnetite
    hematite
    limonite

Lead: galena

Zinc: sphalerite

Gangue: quartz
    calcite
    sericite
    biotite
    chlorite
    fluorite

Gold occurs (1) as microscopic grains disseminated through the country rock; (2) as wire gold and grains in quartz veins; (3) as microscopic grains in disseminated pyrite; and (4) as placer nuggets, grains, and colors. All of this gold contains some silver.

The only *silver* in the district occurs alloyed with gold.

Chalcopyrite, the most abundant of the copper-bearing minerals, occurs sparingly in the American Girl mine. It was probably the primary source for most of the oxidized copper which can be seen in scattered outcrops all over the district.

Among the supergene *copper* minerals are covellite, chalcocite, malachite, azurite, chrysocolla, cuprite, and copper, all in minor amounts.

Pyrite is the most abundant sulfide in the region. It occurs as a primary mineral in veins and in disseminated deposits.

Magnetite has been found occurring as a primary vein mineral in very small amounts at several isolated spots in the workings of the American Girl mine.

Hematite has been collected as shiny gray mirror-like plates from a number of mineralized veins throughout the whole district. It is most commonly found penetrating calcite crystals along their cleaveage planes.

Limonite occurs in the oxidized zone wherever there has been mineralization.

Galena and small amounts of *sphalerite* have been identified as occurring along with chalcopyrite in the ores of the American Girl mine.

Quartz is the most abundant gangue mineral of the whole district. It forms the bulk of most of the vein deposits and is an important constituent in all disseminated deposits.

Calcite, and much less commonly *fluorite,* occur in minor amounts as gangue minerals in conjunction with most of the mineralization in the area.

Sericite and *biotite* occur in mineralized zones as small, fresh-looking crystals with subparallel orientation. They also occur in large micaceous lenticular masses locally along the main fault of the American Girl mine.

Chlorite is generally found in the mineralized zone in veinlets with calcite or quartz, though some of it appears disseminated.

The best opportunity to study the mineralization was provided by the American Girl mine. Consequently, the remarks in the following few pages are strictly applicable to that mine only, although they apply in general to the other prospects and mines.

Wall-Rock Alteration

The country rock in the American Girl mine has undergone considerable alteration by mineralizing solutions. The country rock has been somewhat sheared but the extent to which this shearing brought about mineralogical changes is not great, except perhaps in the close proximity of the shears themselves. This general but weak dynamic metamorphism may be observed persistently throughout the mine.

Locally, especially along the main fault, shearing stresses acting in combination with a small amount of introduced material succeeded in producing nonpersistent lenses of sericite.

To a later phase belong the solutions which produced the major alterations and metallization. Chloritization and sericitization are the most important types of alteration, particularly in the metamorphic rocks. Feldspars and some quartz have also been introduced into the arkosite. Areas of alteration of quartz diorite are rare.

The typical barren wall rock throughout most of the American Girl mine is green-gray, generally fine-grained but occasionally porphyritic, containing large gray to pink crystals of feldspar. The porphyritic variety of alteration is best observed in the footwall drift of the 500 level of the mine. In the hand specimen (C. M. No. 43) the nature and origin of the rock remain highly uncertain. In thin-section under the microscope, however, this wall rock is really identified.

Principal minerals:

Orthoclase, 35 percent, occurs in roughly rounded grains of small to medium size. It is partly altered to kaolin and in places very small flakes of sericite have developed in the crystals.

Microcline, 16 percent, small to medium-sized gray grains which are distinct from the large pink metacrysts described under alteration minerals.

Andesine, 3 percent, appears as small, rounded grains scattered throughout the groundmass.

Quartz, 30 percent, most commonly occurs as small rounded grains. Quartz also occurs to a very small extent as an alteration mineral.

Accessory minerals:

Include zircon, apatite, sphene, and topaz.

Alteration minerals:

Chlorite, 8 percent, is the only important dark mineral in the rock. Characterized by its ultra-blue abnormal interference color, it probably represents the variety penninite.

Microcline, 4 percent, occurs as large pink metacrysts which replace the earlier mineral grains indiscriminately. The metacrysts often bear inclusions of quartz and occasionally of the less common minerals.

Quartz occurs in one or two small veinlets penetrating the microcline metacrysts.

Calcite and pyrite are present as a few grains replacing the country rock.

Sericite and kaolin are developed to a small extent in the feldspars.

The rock was derived from an arkosic sediment, probably identical with Tumco arkosite. Hydrothermal alteration has changed the megascopic appearance of the rock considerably with little effect on its chemical composition and structure. Original dark minerals (probably mostly biotite) have been entirely chloritized. Microcline has been introduced or reworked in place to form medium to large-sized pink metacrysts. Minor amounts of quartz likewise have been introduced or reworked. A few grains of pyrite and calcite give evidence of the actual infiltration of mineralizing solutions. The sericitization of the feldspars may have occurred at the time of this later mineralization. (There is no proof of the time of sericitization in the wall rock under discussion. For evidence that sericitization may have been closely related to ore deposition, see below.) Kaolin in the feldspars may have been developed either by the action of supergene ground waters or by hydrothermal action. Chloritized rock of the type described above is common in all of the workings of the mine whether in rich ore or barren waste, whether in hanging wall or in foot wall. The degree of intensity of chloritization decreases with increased distance from the ore-bearing area.

In contrast to the widespread weak chloritization of the wall rock is a localized and intensive alteration to sericite and biotite. This sericite-biotite alteration occurs in the American Girl mine only in areas in close proximity to the main fault or to minor subparallel faults. All of the wall rock which was altered in this manner constituted economically profitable ore. Perhaps almost half of the total ore of the mine was derived from these heavily metallized sericite-biotite alteration zones.

In the hand specimen (C. M. No. 45) the ore appears to consist of abundant euhedral pyrite crystals in a very fine-grained, dark-gray, indistinctive groundmass. Numerous fine stringers cut the rock. Under the microscope, it appears that none of the original minerals of the rock have been left unaltered, except perhaps apatite.

Accessory minerals:

Apatite, 1 percent, occurs in small, rounded grains, and is scattered all through the rock.

Alteration minerals:

Sericite, 57 percent, makes up the bulk of the groundmass. It is very fine grained and almost completely lacking in any crystal alignment.

Biotite, 30 percent, occurs in small, fresh-looking crystals with subparallel orientation. They are very rarely replaced or altered in any way.

Quartz, 2 percent, calcite, 4 percent, and chlorite occur in veinlets and also disseminated throughout the rock.

Magnetite occurs as a dust disseminated through the rock.

Pyrite, 5 percent, forms large euhedral crystals which cut across the other minerals, replacing rather than displacing them.

The magnetite as well as apatite may have been an original rock mineral, but it must have suffered recrystallization. All of the other minerals are the products of wall-rock alteration. From the nature of this highly altered specimen (C. M. No. 45) there is no clue to the original character of this ore-bearing rock.

Veins

In addition to the quartz, calcite, and chlorite veinlets which penetrate the wall rock, several strong veins occur in the American Girl mine. All of these major veins follow faults along which the wall rock is shattered on either side. The dominant vein mineral is quartz. Pyrite, chalcopyrite, galena, and magnetite have been observed in these veins. Vein pyrite is rarely in euhedral crystals, in contrast to euhedral pyrite in the altered wall rocks. Perhaps the sphalerite and pyrrhotite reported in the concentrates were also derived from these metal-bearing quartz veins. Pink orthoclase and deep purple fluorite have been occasionally noted in vein quartz. Most commonly the veins are massive and single, but occasionally they occur as composite veins or lodes. A few very thin veins have minor cavities and vugs lined with quartz and euhedral pyrite. Others contain calcite.

Metallization

Along with the wall-rock alteration there were introduced a number of metallic elements, mostly in the form of sulfides. All data on metallization was obtained from a report by the American Cyanamid Company.[25] The flotation concentrate includes pyrite, chalcopyrite, chalcocite, covellite, bornite, sphalerite, galena, pyrrhotite, magnetite, hematite, limonite, and gold.

TABLE 2

ASSAYS OF THE FLOTATION CONCENTRATE

	American Cyanamid Co.	Smelter
Gold	6.75 oz. per ton	6.88 oz. per ton
Silver		3.50 oz. per ton
Copper*	2.85%	3.05%
Iron	31.93%	30.50%
Sulphur	32.93%	32.50%
Lime		1.50%
Alumina		4.10%
Silica		20.60%
Insoluble	25.90%	

(* The percentage of copper in both samples is lower than average. 5% copper is usual.)

Assays of the different mesh sizes after screen analysis reveal that most of the values fall into the minus 325-mesh group. The minus 325-mesh contained 54.74 percent of the total gold, 70.65 percent of the copper, 45.81 percent of the iron, and 27.81 percent of the insoluble material.

Examination of the flotation concentrate under the microscope showed that the metallic mineral constituents occurred in both free and locked mineral grains. Pyrite was the most abundant mineral constituent. Most of the pyrite occurred in apparently free mineral grains. An appreciable proportion of the pyrite contained inclusions of other mineral constituents, especially chalcopyrite, sphalerite, limonite, and quartz.

Of the copper-bearing minerals, about 66 percent were chalcopyrite and about 34 percent were chalcocite, along with a little covellite and bornite. About 76 percent of the copper metal content occurred in apparently free mineral grains and about 24 percent occurred in locked mineral particles, especially as minute inclusions of chalcopyrite in pyrite.

Occurrences of gold were noted in free mineral grains and in locked particles. Locked gold particles 1 to 30 microns in diameter were most common in pyrite and chalcopyrite. Gold was also found both in limonite and quartz. The limonite was generally pseudomorphous after pyrite.

Four panner products and a slime product were obtained from a sample of the concentrate on a Haultain super-panner. These products were all assayed for gold, copper, iron, and insoluble material. Of the gold, 21.94 percent was panned out as free gold. The panner iron concentrate assayed 6.04 oz. of gold per ton and carried 38.40 percent of the gold. The panner copper concentrate assayed 10.24 oz. of gold per ton and carried 17.82 percent of the gold. The panner tailing contained 4.10 percent of the gold, and assayed 1.32 oz. of gold per ton. In the slime portion of the sample was 17.74 percent of the gold. The slimes assayed 5.28 oz. of gold per ton.

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[25] American Cyanamid Company. Ore Dressing Laboratory. Microscopical examination of a flotation concentrate from the American Girl Mine. Private Report. 1938.

The study of the ore minerals has not been carried far enough to permit detailed discussion of the paragenesis of the ore minerals. Since most of the gold occurs as minute locked particles in the pyrite and chalcopyrite, the interpretation that is placed upon these relationships (whether inclusion or replacement) will determine in a large measure the nature of any hypothesis of paragenesis.

A series of drawings made from photographs of polished sections of the concentrates[26] illustrates the nature of the occurrence of the metallic minerals and their relationships to each other (Fig. 15).

Omitting for lack of evidence any statement regarding the paragenetic relationships of gold and quartz, these drawings seem to show the following mineral paragenesis:

Earliest: pyrite
chalcopyrite
Latest: sphalerite

Relationship Between Wall-Rock Alteration, Veins, and Metallization

Surrounding the main fault and some of the minor faults of the American Girl mine lies an aureole of chloritized and feldspathized country rock. Bodies of rock highly altered to dense, fine-grained masses of sericite and biotite crystals occur in shoots and lenticular deposits in close association with the breaks. Almost all of the alteration took place in the arkosite wall-rock to the west of the American Girl shaft. Nothing beyond a little chloritization occurred in the quartz diorite which lies to the east.

Whether these two types of alteration represent successive stages or different phases of the same stage of mineralization, the metallization occurs dominantly with the sericite and biotite. Massive quartz veins, which occasionally carry inclusions of sericite-biotite ore, were deposited during the next stage. More pyrite and gold, along with the less common sulfide minerals and fluorite were deposited in the quartz veins. The exact time of deposition of the relatively unimportant calcite stringers was not determined, though it is suggested that they followed the period of metallization.

Origin of the Ores

While some of the materials involved may have been derived from the decomposition of the country rock, most of the chemical elements were introduced. Furthermore, the source of these introduced elements was probably a cooling magma. Sericitization, which represents the most intensive type of alteration, is considered to be indicative of the alkalinity of the solution.[27]

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[26] American Cyanamid Company, *op. cit.* 1938.

[27] Graton, L. C. Nature of the ore-forming fluid. Econ. Geol., vol. 35, supplement to No. 2, pp. 197-358. 1940.

The metallization, wall rock alteration, and vein structure, as discussed above are typical of mesothermal ore deposits.

Age of Mineralization

Mineralization in the American Girl mine was obviously controlled by the main fault and its subsidiary faults. In every case, wall-rock alteration and metallization decreases with increasing distance from these breaks. Hence the mineralization is post-faulting. In several places in the footwall in the American Girl mine small sulfide-bearing veins have been found cutting pegmatite dikes. Hence, the ore mineralization occurred after the pegmatites intruded. In the Sovereign East mine of Tumco Valley the pegmatite dikes are seen to be offset by the main thrust fault in the mine.

From these structural relationships it is concluded that the ore is post-faulting and the faulting is post-pegmatite. The pegmatites are known to be the youngest of the coarsely crystalline rocks. Hence the ore mineralization is younger than the main period of intrusion. Though at present there is no apparent means of telling how much younger, it is believed that these mesothermal gold-bearing quartz veins, like those of southern Yuma County, Arizona,[28] may be of late Mesozoic age.

GOLD PLACERS

Distribution

The alluvial gravels of Jackson Gulch and the Padre Madre Valley are reported to have yielded rich returns in placer gold. Pits and dump piles testify that these two alluvial areas were thoroughly explored and exploited. At the present time there is very little gravel left which has not been worked at least once.

Gold Content

Rumor has it that these placer deposits were very rich. However, no estimate can be made of their total yield. In Jackson Gulch the writer witnessed the dry washing of about half a cubic yard of previously undisturbed gravel. This gravel yielded approximately $5.00 in gold, most of which was in the form of small, relatively unworn nuggets. The preponderance of larger pieces was probably due to the loss of the fine colors in the dry washing.

TAILINGS

The three major tailings piles of the district have all been reworked to a greater or less degree. The Tumco tailings are being cyanided in a small scale operation.[29] Old tailings and dumps of the American Girl were extensively milled and concentrated by O'Brien Mines, Inc. Cargo Muchacho tailings have been reworked more than once. Holmes and Nicholson were the last to operate on them.

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[28] Wilson, E. D. Geology and mineral deposits of southern Yuma County, Arizona. Univ. of Arizona, Ariz. Bur. of Mines Bull. 134, p. 46. 1933.

[29] Calif. State Mineralogist's Report, vol. 34, p. 9. 1938.

METAL MINES

MINES IN THE LEUCOGRANITE

Mineralized zones occur on faults in or near metamorphic inclusions. The attitude of the faults is parallel to the relic structure of the inclusions. The mineralization consists essentially of quartz veins bearing pyrite, a little chalcopyrite, specular hematite and gold.

La Colorada mine (Plate II, no. 1) consists of nine claims owned by Mr. and Mrs. Mike Muller and Earl Goff of Calexico, California. The vein strikes eastward and dips 30 to 35 degrees.

Golden Queen prospect (Plate II, no. 2) is owned by a Mr. Miller. The vein lies on a flat-lying fault of variable strike, which averages roughly NW, while the dip is less than 20 degrees SW.

MINES IN THE TUMCO ARKOSITE OF TUMCO VALLEY

Mineralized zones occur on and near faults parallel to the regional structure. Perpendicular transverse faults form a minor ore control, as in the Golden Cross mine. Drag folds in the hanging wall also localized the deposition of the ore, *e.g.* the large-scale drag-folds in the 450 stope and 700 stope of the Golden Queen mine. The mineralization consists of quartz, pyrite, chalcopyrite, and gold. In the past, some of these mines were operated on a very large scale.

Coffee Pot prospect (Plate II, no. 3) consists of six claims owned by Eddie Coffee, J. L. Hardy, Henry Stroud, Mike Olathe, Henry H. Austin, and Jose Davis. Vein attitude is (strike) N. 84°E., (dip) 34°S. A winze had been sunk 65 feet down the dip in January 1939.

King mine (Plate II, no. 4) differs from other mines in this group in its steep dip near the surface. The attitude of the main fault is N. 72° W., 52°S.

Golden Cross group of mines now under the control of Thomas L. Woodruff of Ogilby had a total production estimated at more than $3,000,000. All were large mines with inclined shafts extending down the dip of the main fault for more than 1,000 feet, and with many thousands of feet of workings. Ore occurred disseminated in the hanging wall. All were mined by shrinkage stoping.

Golden Queen mine (Plate II, no. 5). The attitude of the footwall is N. 52°E., 26°S. Pegmatite stringers in the hanging wall are shown in a picture of the shaft (Fig. 7).

Golden Cross mine (Plate II, no. 6). Footwall attitude is N. 57°E., 37°S.

Golden Crown mine (Plate II, no. 9). Footwall attitude is N. 86°W., 22°S.[30]

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[30] California State Mineralogist's Reports, vol. 12, pp. 240-241. 1893-1894; vol. 13, pp. 331, 337-339. 1895-96; vol. 15, pp. 726-728. 1913-1914; vol. 22, pp. 257-258. 1926.

Draper, M. Private Report on the American Girl Mine. 1911.

U. S. Bureau of Mines. U. S. Department of Commerce. Mineral resources of the U. S. Washington. 1924-1931. Minerals yearbook-review. Washington. 1932-1933.

U. S. Bureau of Mines. U. S. Department of Interior. Minerals yearbook-reviews. Washington. 1933-1939.

U. S. Geological Survey. Mineral resources of the U. S. Washington. 1882-1923.

Sovereign mines, East and West (Plate II, nos. 7 and 8; also Fig. 11) owned by Thomas L. Woodruff. Total production for 1937-38 more than $50,000. The property is still being operated (1940). Ore occurs in the footwall under a fault of variable attitude; strike N. 72°-30°E., dip 20°-30°S. In the Sovereign East mine, workings extend more than 200 feet down the dip and over 350 feet along the strike. Free gold occurs in a quartz vein 20 to 70 inches thick and averages $10.00 to $15.00 per ton.[31]

Other properties in the Tumco arkosite include Banner mine, Delta prospect, and Desert King mine.[32]

AMERICAN GIRL MINE (Plate III)

This mine (Plate III, no. 12) is covered by 18 claims, which also include the American Boy mine (Plate II, no. 13). The American Girl was recently operated by O'Brien Mines, Inc. Early in 1939 these holdings were incorporated with properties controlled by Sidney B. Wood, Jr., to form Allied Mines Inc., with Mr. Wood as general manager. Operation of the mine ceased in the summer of 1939. An estimate of the total production of the American Girl mine from July 1936 to May 1, 1939 is 119,000 tons of ore mined, yielding $575,000 in gold, silver, and copper. Earlier production had yielded:

1892-1900	30,000 tons	$105,000 gold
1913-1916	20,000 tons	$131,000 gold

A well drilled in alluvium to the southwest of the range about 2.5 miles from the mine supplied water for the mine and mill (for analysis see Table 3). Water for domestic use was trucked from Irvin well in Ogilby.

The accompanying plan of the underground workings shows the extent of operations. The ore occurs on and near a thrust fault which dips 30°S. near the surface and 25°S. at depth. Minor cross faults which intersect the main thrust fault have locally shattered the wall rock and have determined to a considerable extent the localization of intense wall-rock alteration and metallization. The nature of the wall rock, wall-rock alteration, and metallization have been discussed above. The Tybo shaft of the mine is shown in (Fig. 8).[33]

The American Boy mine differs from the American Girl in distribution of wall-rock types. The entire hanging wall consists of quartz diorite; the footwall, of metamorphosed arkosite. The structure is similar to that of the American Girl, but wall rock alteration and metallization are not so intense.

Nearby properties similar in geology include the Ogilby group, the Mayata and Englewood claims, and the Yuma and Arizona claims.[34]

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[31] California State Mineralogist's Report, vol. 34, p. 9. 1938. U. S. Bureau of Mines. U. S. Department of Interior. Minerals yearbook-reviews. 1938 and 1939.

[32] California State Mineralogist's Reports, vol. 13, pp. 331-332. 1895-96; vol. 14, p. 729. 1913-1914; vol. 22, pp. 255-256. 1926.

[33] California State Mineralogist's Reports, vol. 13, p. 331. 1895-96; vol. 14, pp. 728-729. 1913-14; vol. 22, p. 255. 1926; vol. 34, p. 9. 1938.
Draper, Marshall. Private report on the American Girl Mine. 1911.

[34] California State Mineralogist's Reports, vol. 14, p. 729. 1913-14; vol. 22, p. 259. 1926.

TABLE 3

ANALYSIS OF WATER FROM THE AMERICAN GIRL WELL

Dissolved Solids

Silica	1.30	grains per U. S. gal.
Aluminum oxide	0.25	
Iron oxide	0.01	
Calcium	24.41	
Magnesium	0.90	
Sodium	82.64	
Sulphate	21.16	
Chlorine	156.52	
Carbonate	None	
Bicarbonate	2.14	
Total solids	289.36	
Total non-volatile solids		288.27
Total hardness as $CaCO_3$		64.74

Hypothetical Combinations

Silica	1.30	grains per U. S. gal.
Aluminum oxide	0.25	
Iron oxide	0.01	
Calcium bicarbonate	2.84	
Calcium sulphate	29.98	
Calcium chloride	41.30	
Magnesium bicarbonate	None	
Magnesium sulphate	None	
Magnesium chloride	3.53	
Sodium bicarbonate	None	
Sodium carbonate	None	
Sodium sulphate	None	
Sodium chloride	210.15	
Total solids	289.36	

Determinations

Carbon dioxide uncombined in p.p.m.	2.0
Hydrogen sulphide in p.p.m.	None
Specific electric conductance	Not determined
Hydrogen Ion concentration	7.7
Boron in p.p.m.	0.4
Color (filtered)	None
Odor	None
Taste	Saline
Turbidity (filtered)	None

Smith-Emery Co. Chemical analysis of water from the American Girl well. Private report, March, 1936.

GUADALOUPE MINE

This mine, owned by Nat Kenison, is located near the east end of Obregon Valley (Plate II, no. 14). Disseminated pyrite occurs in a large quartzitic inclusion in quartz diorite along a fault which parallels the orientation of the inclusion. The fault strikes N. 7°W. and dips 52°E.[35]

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[35] California State Mineralogist's Reports, vol. 14, p. 729. 1913-14; vol. 22, p. 255. 1926.

MINES IN QUARTZ DIORITE

Within this rock quartz veins occur along minor generally steep-dipping faults and shear zones. Wall-rock alteration in the form of chloritization is intense in the mines of Madre Valley, but is of limited extent elsewhere. Hematite is common. Gold occurs free or in pyrite. Although the values are generally spotty a few of these mines have been very productive.

Pasadena mine (Plate II, no. 24). An ore-bearing silicified shear zone, with an attitude of N. 30°E., 33°SE., has been prospected by five adits at different levels.[36]

Cargo Muchacho mine (Plate II, no. 23) was leased and worked by Holmes and Nicholson in 1936 and again in 1939. Quartz veins occur in a silicified shear zone 2 to 8 feet wide. Its attitude is approximately N. 4°E., 48°E. To the south the mineralized zone crosses the contact from the quartz diorite into quartz monzonite. Values occur only where quartz diorite is the wall rock.[37]

Blossom mine (Plate II, no. 18; also Fig. 9) is an old property which was re-opened in 1938-39 by a Mr. Stubbins. The quartz diorite country rock is abundantly sheared and highly chloritized. There are many small quartz stringers in the mine, but none of them is persistent. The 200-foot Valencia shaft and several hundred feet of drift explore a mineralized fault zone with an attitude of N. 15°-25°W., 50°SW.[38]

Padre and Madre mines (Plate II, nos. 19-21; also Figs. 10 and 12) are owned and operated by the Holmes and Nicholson Mining Company. The ore occurs in or near a dull-gray quartz vein which follows a fault of variable attitude. Its strike ranges from N. 50°W. to N. 50°E. Dip remains almost constant at approximately 24°S. A persistent breccia dike a few inches to a foot thick occurs generally in the footwall parallel to the vein.[39]

Other properties in the quartz diorite include Occidental mine, south of Pasadena mine; Gray Eagle prospect, east of Pasadena mine; and Little Bear prospect (Plate II, no. 22). Gray Eagle, owned by C. J. Creese has an attitude of N.57°E., 36°SE. Little Bear is owned by Roy Bennett and others of Yuma, Arizona. It is characterized by a zone of numerous small quartz stringers with an attitude of N. 60°E., 45°SE.

MINES IN QUARTZ MONZONITE

A number of prospects have been opened in quartz monzonite on small veins similar to those which occur in quartz diorite. None of them has developed into a mine.

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[36] California State Mineralogist's Reports, vol. 11, p. 386. 1891-1892.; vol. 12, p. 242. 1893-1894; vol. 13, pp. 341 and 343. 1895-1896; vol. 14, p. 729. 1913-1914; vol. 22, p. 260. 1926.

[37] California State Mineralogist's Reports, vol. 6, p. 81, Pt. I. 1886; vol. 11, pp. 385-386. 1891-92; vol. 12, p. 239. 1893-1894; vol. 13, pp. 333-334. 1895-96; vol. 14, p. 729. 1913-1914; vol. 22, p. 255. 1926; vol. 34, p. 9. 1938.

[38] Calif. State Mineralogist's Reports, vol. 12, p. 238. 1893-94; vol. 13, p. 332. 1895-96; vol. 14, p. 729. 1913-14; vol. 22, p. 255. 1926.

[39] Register of Mines and Minerals. San Diego Co., p. 6. 1902.
Calif. State Mineralogist's Reports, vol. 12, p. 242. 1893-94; vol. 14, p. 729. 1913-14; vol. 22, p. 259. 1926. vol. 34, p. 9. 1938.

Whitecap prospect (Plate II, no. 15), five claims owned by J. D. Northcott, J. H. Williams, R. van Patten and B. J. Hanna. Vein attitude N. 33°W., 51°E.

Tee Wee prospect (Plate II, no. 16), three claims owned by Alex Crawford, may represent an extension of the Whitecap vein.

ECONOMIC GEOLOGY—NONMETALS

GENERAL DESCRIPTION

The non-metallic products of the Cargo Muchacho district consist of sericite and kyanite. Though both of these minerals have been mined extensively in the district, their production is sporadic and follows closely the demands of the market. Five sericite quarries have been opened up and two kyanite deposits have been worked. Most of the production has come from one sericite quarry and from one kyanite quarry.

The mineralogy and general geology and possible origin of these deposits have been discussed above.

NONMETAL MINES

SERICITE IN TUMCO FORMATION

Occasionally, near pegmatite dikes in the Tumco arkosite, the country rock is completely altered to sericite. This grades outward first into a sericite schist bearing large feldspar augen, then to a biotite-feldspar schist, and finally into normal Tumco arkosite.

A prospect pit in the bottom of an arroyo a few hundred feet north of the Golden Queen mine and a few sporadically active quarries (Plate II, no. 10) at the southwest end of Tumco Valley exemplify this type of occurrence.

SERICITE IN THE VITREFRAX FORMATION

This occurrence of sericite has been briefly described above. The largest and most active sericite quarry in the district is located on Micatalc Hill (Plate II, no. 11). An open cut has been worked since about 1930 by Micatalc Inc., under C. E. Allebrand of Los Angeles.

KYANITE IN THE VITREFRAX FORMATION

The geology of the kyanite deposits has been briefly discussed above.

Several small quarries have been worked on Micatalc Hill and in its vicinity.

Ogilby kyanite deposits. 10 claims owned by Vitrefrax Corp., 5050 Pacific Boulevard, Los Angeles. A large open cut on Vitrefrax Hill (Plate II, no. 17) supplies an average of 100 tons per year of kyanite. The best ore in the mine averages 40 percent kyanite. The kyanite is separated from the quartz by crushing and screening in the Micatalc mill (Fig. 13.)[40]

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[40] California State Mineralogist's Reports, vol. 13, p. 333. 1895-1896; vol. 22, pp. 268-270. 1926; vol. 27, pp. 451-452, 455-457. 1931.
California State Div. of Mines Bull. 99, pp. 87, 121-122. 1928.
Riddle, F. H. Minerals of the sillimanite group. Eng. and Mining Jour., vol. 133, no. 3, p. 141. 1932.

WATER SUPPLY

GROUNDWATER LEVEL

The only available water in quantity in the district occurs as groundwater in the alluvial fan to the west of the range.

A series of well records (see Table 4) indicates that the groundwater level is highest near the Colorado River. Hence it is concluded that the Colorado River is the source of supply for the groundwater of the Ogilby region. With an intake point at a high of around 150 feet above sea level, for example at El Oro on the Colorado, the groundwater level drops away to the north and west. The fact that the water table does not rise as the mountains are approached indicates that almost no groundwater is contributed from the mountains.

AMOUNT AND TYPE OF GROUNDWATER

Not one of the wells listed in Table 4 has ever been pumped dry, or for that matter ever had its level lowered appreciably. Hence, the gravels penetrated by the wells must be highly permeable as well as adequately supplied with groundwater.

All of the wells around Ogilby, except for the American Girl company well, yield water fit for domestic use. The first water struck in drilling the American Girl well was sweet, but insufficient in quantity. Deeper drilling gave an unlimited supply of saline water satisfactory for all except drinking purposes (see Table 3 for analysis).

APPENDIX B

TABLE 4

WELL RECORDS

Well	Location	Elevation	Depth water stands	Depth water struck	Total depth well	Ground-water elevation	Type of water
Walker	T15S R20E Sec. 4	460	410	410	521	50	Domestic
American Girl	T15S R20E Sec. 23	450	368	325	475	82	Saline
Irvin	T15S R20E Sec. 34	310	220		390	90	Domestic
Maxey	T16S R21E Sec. 26	200	110		150	90	Domestic
Highway maintenance	T16S R20E Sec.	170	100	100	190	75	Domestic
Buttercup Valley	T16S R20E Sec.	180	90	90	90	90	Domestic
Gray	T16S R20E Sec. 32	170	90	90	120	80	Domestic
Gordon	T16S R19E Sec. 36	165	90		125	75	Domestic
Old County	T16S R20E Sec. 32	170	110		120	60	Domestic
New County	T17S R18E Sec. 1	125	80		140	45	Domestic
Glamis	T13S R18E Sec. 28	350					Saline
Amos	T12S R16E Sec. 24	259	268	268	550	9	Saline

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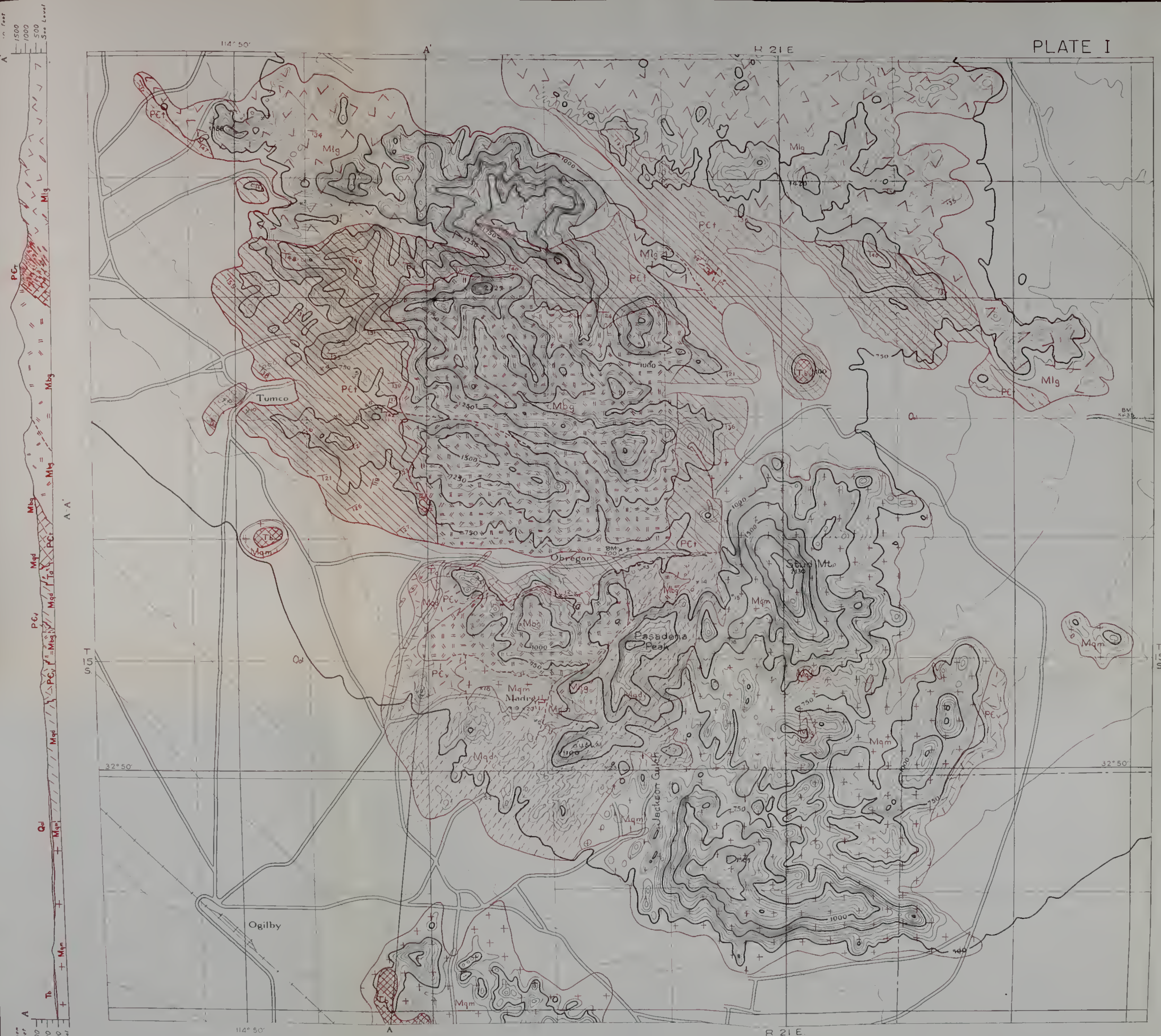
PLATE II



EXPLANATION

SEDIMENTARY ROCKS

Qal
ALLUVIUM
(UNDIFFERENTIATED)

IGNEOUS ROCKS

Tb
BASALT
(REMNANTS OF FLOWS)

Ta
ANDESITE
(DIKES)

Mlg
LEUCOGRANITE
(INTRUSIVE MASSES)

Mbg
BIOTITE GRANITE
(INTRUSIVE MASSES)

Mqm
QUARTZ MONZONITE
(INTRUSIVE MASSES)

Mqd
QUARTZ DIORITE
(INTRUSIVE MASSES)

METAMORPHIC ROCKS

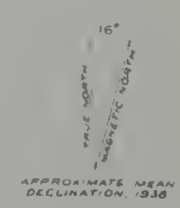
PCt
TUMCO FORMATION
(MASSIVE GRAY ARKOSITE)

PCv
VITREFAX FORMATION
(QUARTZ-KYANITE SCHIST SERICITE SCHIST)

SYMBOLS

Dip and Strike ⟋
Mine ⚒
Fault – – –

Adapted from the U S G S topographic map
YUMA QUADRANGLE, CALIFORNIA-ARIZONA
Topography by D L Reaburn
Surveyed in 1902-03



APPROXIMATE MEAN DECLINATION, 1938

GEOLOGIC MAP OF THE

CARGO MUCHACHO MOUNTAINS, CALIFORNIA

Showing location of mines and prospects

Scale

0 1 2 Miles
0 5000 10,000 Feet

Contour interval 50 feet
Datum is mean sea level

1939

Geology by P C Henshaw
1938

LIST OF MINES AND PROSPECTS

(Locations shown by numerals)

1	Colorado	13	American Boy
2	Golden Queen	14	Guadaloupe
3	Coffee Pot	15	Whitecap
4	King	16	Tee Wee
5	Golden Queen	17	Vitrefrax
6	Golden Cross	18	Blossom
7	Sovereign East	19	Padre
8	Sovereign West	20	Madre No 1
9	Golden Crown	21	Madre No 2
10	(Talc quarry)	22	Little Bear
11	(Talc quarry)	23	Cargo Muchacho
12	American Girl	24	Pasadena

ACCOMPANYING STATE MINERALOGIST'S REPORT XXXVIII, APRIL, 1942

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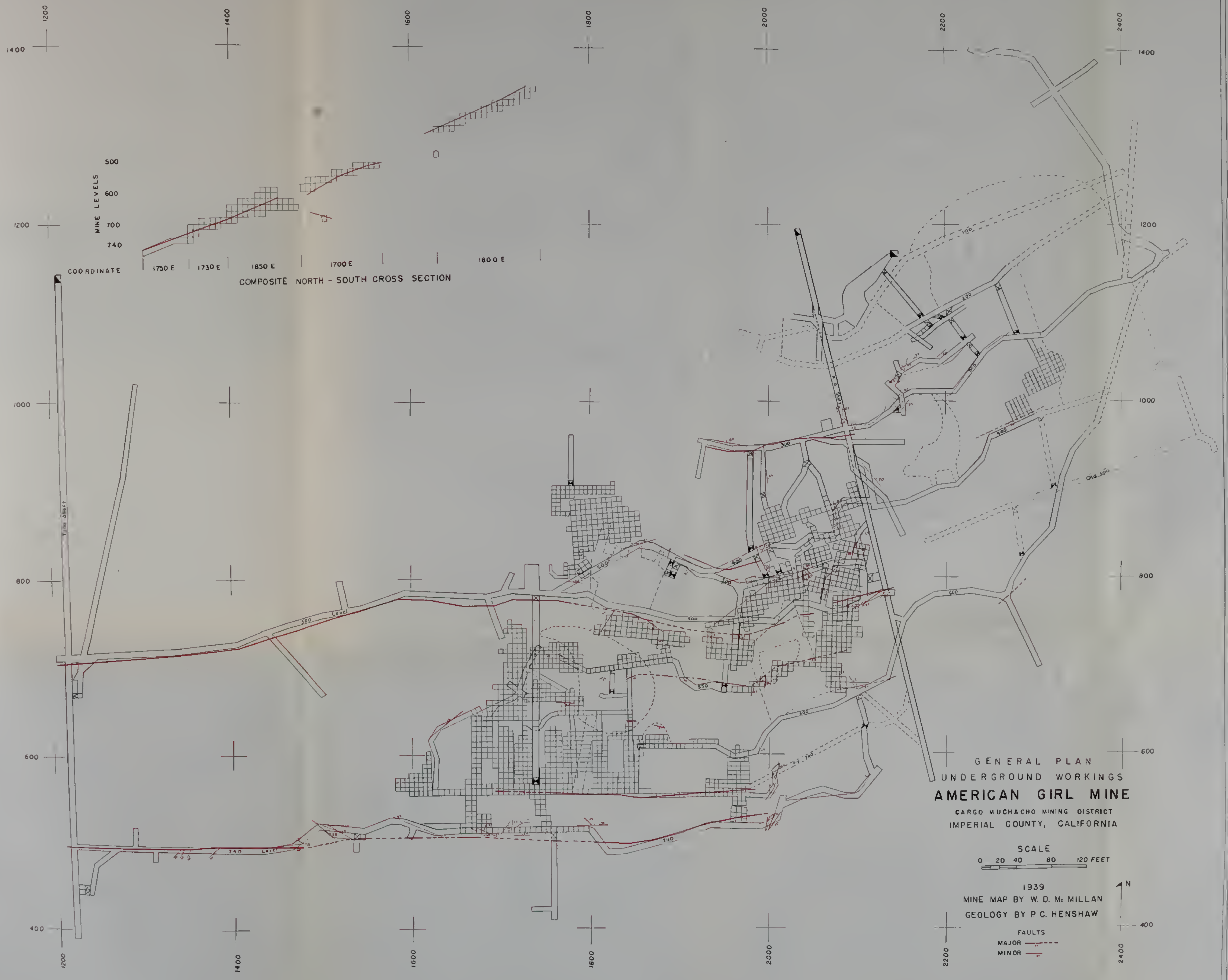

GENERAL PLAN
UNDERGROUND WORKINGS
AMERICAN GIRL MINE

CARGO MUCHACHO MINING DISTRICT
IMPERIAL COUNTY, CALIFORNIA

SCALE
0 20 40 80 120 FEET

1939
MINE MAP BY W. D. McMILLAN
GEOLOGY BY P. C. HENSHAW

FAULTS
MAJOR
MINOR

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ACCOMPANYING STATE MINERALOGIST'S REPORT XXXVIII, APRIL, 1942

SPECIAL ARTICLES

Detailed technical reports on special subjects, the result of research work or extended field investigations, will continue to be issued as separate bulletins by the Division, as has been the custom in the past.

Shorter and less elaborate technical papers and articles by members of the staff and others are published in each number of CALIFORNIA JOURNAL OF MINES AND GEOLOGY.

These special articles cover a wide range of subjects both of historical and current interest; descriptions of new processes, or metallurgical and industrial plants, new mineral occurrences, and interesting geological formations, as well as articles intended to supply practical and timely information on the problems of the prospector and miner, such as the text of new laws and official regulations and notices affecting the mineral industry.

IMPERIAL CARBON DIOXIDE GAS FIELD[a]

JAS. C. BRANSFORD[b]

On the southeast shore of the Salton Sea near Niland, Imperial County, natural Carbon Dioxide (CO_2) gas is being converted into dry ice in two well equipped plants, the capacity of which is nearly sixty tons daily. This unique industry, started here in 1933 on an experimental basis, is now expanding due to improved markets created in part by its many new uses in war industries.

The strategic advantage of this locality over its artificial CO_2 competitors in the eastern U. S. industrial area, where the product is secured from coke ovens, lime kilns and metallurgical plants, is demonstrated by its obvious superiority of transportation facilities and market outlets in the famous Coachella-Imperial Valley fruit and vegetable district, and its proximity to the large Southern California war industries.

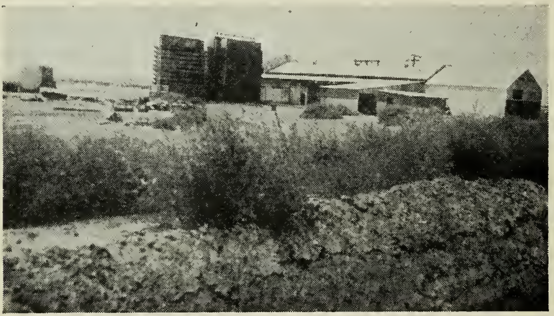

FIG. 1. Artesian hot (186°) water well with carbon dioxide showing in NE¼ Section 2-9-12

In manufacturing dry ice the gas is first purified and then compressed in three stages to 800 to 1000 lbs. per square inch until it becomes a liquid. Releasing the liquid from that pressure causes it to chill to CO_2 snow, which is then compressed into the usual 10″ cubes of dry ice weighing about 50 pounds. The market price of dry ice is now near $80.00 per ton.

There are at present about fifty different commercial uses to which Carbon Dioxide (gas, liquid and solid) has been adapted. Among these, refrigeration, especially on the freight trains that carry perishable truck garden and orchard products and in ice cream transportation, is one of the main uses of dry ice. One pound of solid CO_2 (dry ice) has the same refrigerating effect at 32° F. as two pounds of ice, and instead of melting to a liquid, as water ice, it sublimes, i.e. it passes directly from a solid to a gaseous state leaving no wet spaces as does water ice.

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[a] By permission and courtesy of *California Oil World and Petroleum Industry*, reprinted from first issue, July, 1942, pp 13-14.

[b] Petroleum Geologist.

In the war industries a mixture of dry ice and alcohol is used to contract steel and other metals to make extra tight "shrink fits" in aircraft engines, tanks and antiaircraft guns, also to shrink cylinder liners in Diesel engines and in valve seats. Again, CO_2 is used in fire fighting equipment, as it reduces the oxygen content of the air to a point where it cannot support combustion.

In the Imperial field there are over forty gas wells, located for the most part in Sections 1, 2, 11, 12, 13 and 14, Township 11 South, Range 13 East, S. B. B. & M. The majority of the wells cement 8⅝″ pipe near 450′ and land 6⅝″ perforated liner on bottom close to 650′.

The resulting production volume is not high, the production of wells varying from 50,000 to 200,000 cubic feet daily, flowing through a ⅛″ to ¼″ bean under pressure of 175 lbs. for several of the wells. However, the resulting gas is rich in Carbon Dioxide (99% pure) and that is practically free from the detrimental H_2S gas. An exception occurred in the southwest edge of the field where a well was abandoned due to excessive H_2S gas.

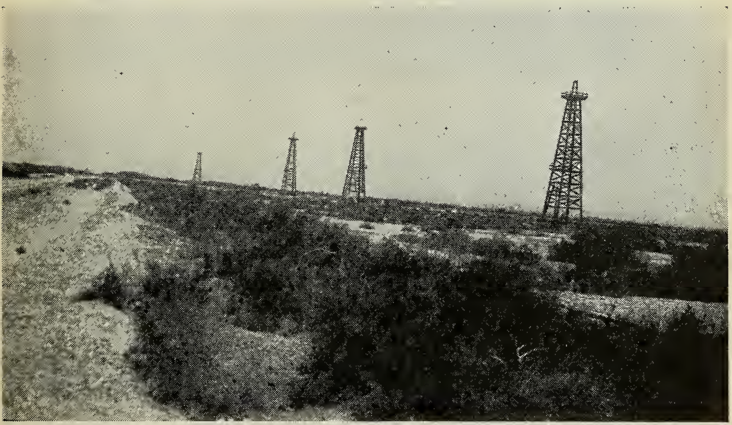

FIG. 2. Imperial Carbon Dioxide Gas Field, view looking north along west line Sec. 1-11-13, Natural Carbonic Products, Inc. wells

From a late issue of the Journal of Geology, a study made by J. L. Soske indicates that the "general opinion among the operators of the district is that the CO_2 gas has resulted from the action of superheated steam and other gases on sedimentary carbonate rocks. They note that 'lime' rocks are present near the producing horizons. On the other hand, the emanations of CO_2 from volcanoes is well known. The Salton volcanoes themselves give off CO_2 and other gases, and it appears more probable that the producing horizons are sedimentary structural traps into which the juvenile magmatic carbon dioxide has migrated."

From a geological standpoint it is interesting to study the field notes and surveys of the U. S. General Land Office made in 1856. These surveys reveal the presence of mud and steam volcanoes or geysers and springs situated along the southeast shore of the Salton Sea for a distance of nearly fifteen miles in length and three miles wide, extending northwesterly along the San Andreas Fault system from the present CO_2 gas field in T. 11 S., R. 13 E. to T. 9 S., R. 12 E. This situation is indicative of decadent volcanic activity and is often associated with CO_2 gas.

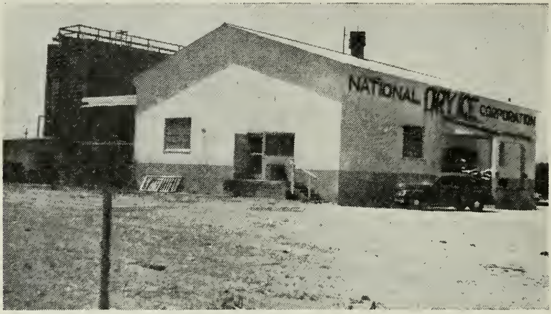

FIG. 3. National Dry Ice Corp. plant in Niland, California

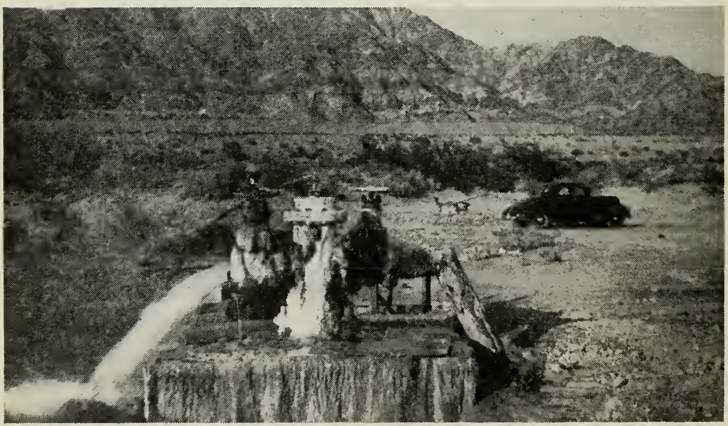

FIG. 4. Pacific-Imperial Dri-Ice, Inc. plant

The results of a geological survey made in 1938 on the Imperial (Niland) CO_2 gas field were in part published in Technical Paper No. 841 of the American Institute of Mining and Met. Engineers. In this report three factors are mentioned, one or more of which is necessary for the accumulation or concentration of natural CO_2 gas, as follows:

1. Proximity to volcanism, extinct, or decadent. Volcanic activity, where it has long been known that the gas evolved is either free or dissolved in the waters of fumaroles, geysers or mud pots.
2. Suitable traps, such as anticlines or domes, which are essential to its collection, in geologic time.
3. Springs or other conduits which provide a means of escape of free or dissolved gas.

Among the companies having large holdings in this gas field, and in surrounding area thought to be favorably situated geologically for Carbon Dioxide exploration, are: the National Carbonic Products, Inc. (George Pepperdine Foundation interest) now drilling its Well No. 43, National Dry-Ice Corp. with its dry ice plant at Niland served with four-mile 4″ gravity pipe line from its gas properties to the west, Sunrise Land Co. with extensive holdings to the northwest, Pacific-Imperial Dri-Ice, Inc. with a dry ice plant on its lease in the field, and Max Cawthon.

THE LEGENDARY "WHITE METAL" AND ITS "ORE"[1]

By C. W. Davis [2]

Under the title "The So-called 'Mysterious' White Metal," by Frank Sanborn, Mineral Technologist, our investigation of this subject was given in the January 1926 Chapter of State Mineralogist's Report XXII, together with a reprint of U. S. Bureau of Mines Information Circular No. 6000 entitled "The Legendary 'White Metal' and its 'Ore'."

Both Report XXII and Information Circular No. 6000 are now out of print.

As the subject continues to arise, the U. S. Bureau of Mines have revised Information Circular 6000 and issued it as Information Circular 7205 which is here reprinted.

INTRODUCTION

As a byproduct of its investigations, the Metallurgical Division of the Bureau of Mines, from time to time is requested to identify rocks that are usually submitted in good faith by prospectors, miners, and others who think they may contain elements of value. In the large majority of instances, cursory inspection or a few simple tests reveal the nature of the barren material, and the Bureau's statement that the material is worthless is ordinarily accepted. Sometimes it is not so easy to convince the hopeful prospector, especially if he has made tests or has been told of experiments that apparently show the presence of some valuable substance. One of the most difficult persons to convince is the seeker of "white metal."

There is a legend that Mexicans and other old settlers in the Southwest knew of an ore that could be used to harden iron or steel. The usual procedure was to heat the metal in contact with the ore by means of a wood fire, then quench in water. Axles of springless wagons so treated were said to have been made "glass hard" and to wear two or three times as long as ordinary axles, and tires so treated were described as "ringing like a bell" when suspended and struck with a hammer. This effect was believed to be due to a "white metal" that was extracted from the ore and alloyed with the iron by the treatment.

Although this story has never been shown to have had any basis in fact, it still appears from time to time under slightly different guises. Consequently various laboratories, at different times during the past 30 years, have received many kinds of rocks (designated as ores) that are supposed to give remarkable properties to metals, such as making them glass hard, extremely tough, or resistant to corrosion. The "ores" submitted include altered diabase, olivine, pyroxenite, obsidian, basalt, amphibolite, pyritic quartzite, magnetite, tourmaline, sandstone, and in fact, almost every known rock. The majority of samples come from California and Nevada, but nearly all Western States are represented.

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[1] Revision of I. C. 6000. Reprinted from U. S. Bureau of Mines Information Circular 7205.

[2] When Information Circular 6000 was written, the author was associate chemist, Rare and Precious Metals Experiment Station, U. S. Bureau of Mines, and the paper was prepared in cooperation with the Mackay School of Mines, University of Nevada. When the circular was revised (October, 1941) the author was assistant chief, Metallurgical Division, U. S. Bureau of Mines.

ACKNOWLEDGMENTS

The author acknowledges the cooperation of those who so kindly informed him of the results of their investigations so that these results might be included in this circular. Harry E. Tufft, formerly of the Bureau of Mines, assisted in preparing the original manuscript.

RESULTS OF TESTS

In the method of treatment usually specified the metal is heated in contact with the rock for the expressed purpose of producing an alloy with the "white metal." Suggested heat-treating temperatures have ranged from 200° F. to that of the electric arc. The favorite heating device is the blacksmith's forge. The extraction of the "white metal" (which, it was said, could be used directly in forming an alloy, for example, by putting a little on a knife blade and heating in a bunsen flame[3]) was described as having been performed by simply melting the "ore," by melting it with fluxes, or by melting it with fluxes and a reducing agent.

In the past, laboratories of the Metallurgical Division have received various samples of this nature. Some of the samples were brought to the Bureau in person by the sponsor, who attempted to demonstrate his process. The results indicate that money expended for investigation of the mysterious white metal and its ore would be wasted.

Tests by the Bureau and other laboratories, following specified procedures, usually have shown that the ores have no outstanding hardening effect, although in a few tests case-hardening resulted either from heating the metal in contact with carbon, which was protected from oxidation by a coating of flux, or from the formation of a crude silicon alloy. Many ordinary fusible rocks, and even fluxes without rock, will give the same results. Some of the claims of glass hardness may be traced to an adherent hard slag that was mistaken for hardened metal. This coating frequently imparted increased resistance to corrosion.

For example, it was alleged that a particular powdered ore, when sprinkled on Norway iron and heated in a forge, would coat the metal with a lustrous, glass-hard, noncorrodible material and that the iron would change to steel. A treated specimen was submitted to the Bureau of Mines laboratory at Berkeley, California.[4] Analysis showed the ore to be obsidian. A small bar of Norway iron was packed in the powdered mineral and heated electrically above the fusion point of the mineral in the absence of carbon. The submerged part acquired a brilliant, silver-like luster but was not hardened or changed in any other way. Apparently, the effect was merely a thorough cleansing of the surface, which doubtless would be less corroded than a surface more or less coated with iron oxide. The alleged glass-hardness of the submitted specimen was shown to be due to small masses of the fused mineral adhering to rough spots on the surface of the metal.

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[3] Investigated at the Mackay School of Mines.

[4] Investigated by L. M. Duschak.

In another test the ore was basalt, and very positive claims were made for its hardening effect. In the attempted demonstration quarter-inch square bars of Norway iron were heated bright red in a forge and dipped in the powdered mineral, this process being repeated until the end of the bar was well-coated with slag. When quenched in water, the coated portion showed a lustrous surface, and when the bar was twisted this part was found to be slightly hardened. The effect, however, was due to case-hardening caused by particles of coke that were not only held in contact with the iron but also protected from oxidation by the coating of fused mineral. Many similar results have been readily explained, leading to the conclusion that claims concerning the action of these ores are largely unsound.

Attempts to extract white metal from such ores, following specified directions, usually have failed to yield any metal, except when the treatment called for high-temperature fluxing with charcoal of a rock that contained considerable iron, in which instance a small quantity of metallic iron was produced. Invariably, the specimens of white metal said to be melted from the ore were impure metals, mostly lead, copper, zinc and iron, or simply slag. In testing some rocks it was found that the lead had been introduced by fluxing the rock with charcoal in an old assay crucible that had contained a little slag high in lead, which was reduced to metallic lead. In some specimens, the lead, copper, or zinc, had been introduced as impurities in the fluxes used for treating the ore or by using a container in which these metals were present, for example, zinc from galvanized iron.

It was claimed that one sample of pulverized ore (volcanic rock), when melted with flux in an electric arc with carbon electrodes, would produce white metal that would harden steel, iron, and copper. A test [5] using a carbon ladle as container showed the white metal to be iron.

Another claim was that white metal could be produced by fusion in a carbon ladle as described, as well as by reduction in crucibles using fluxes and carbon. The product was said to harden copper or brass and to make cast iron malleable. Both of these methods were tested, using the carbon ladle [6] in one and clay crucibles with fluxes of soda and borax, with and without the addition of carbon in the other. Without carbon no metal was produced. With carbon a small quantity of metallic iron, contained in the original ore, was produced.

In several other tests the only metal produced from the ore was iron reduced from the rock by heating with carbon. Lead that had been introduced during extraction of the metal, either from impure fluxes or from the slag retained in old assay crucibles, was another metal commonly found.

One sample, extracted from a basic igneous rock, proved to be impure lead with a little tin and copper and resembled skimmings from molten solder.[7] Another was impure lead [8] that came from the forge where babbitt had been spilled. Still another was virtually pure lead reduced from the fluxes used.[9]

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[5] Investigator, C. C. Anthony, San Francisco, California (1925).

[6] Investigator, F. S. Mulock, chemical engineer, San Francisco (1925).

[7] Analyst, Fletcher Hamilton, State mineralogist, San Francisco, California.

[8] Analyst, A. A. Hanks, chemist, assayer, and metallurgist, San Francisco.

[9] W. L. Piers, assayer and chemist, Denver, Colorado.

White metal said to be produced from limestone was found to be zinc, which probably came from a galvanized can that had been used. Various rocks whose virtues were presumed to be due to their content of platinum, vanadium, uranium or other rare metal had only the slightest traces of these metals or did not contain them at all. They were simply good fluxes and, as such, cleaned iron but had no power to alter its properties. Any incidental hardening probably was due to case-hardening of the iron by the coal, coke, wood, or other fuel used or by carbonaceous matter in the rock. In one test, when the pulverized ore (basalt) was heated according to specific directions in contact with iron in an electric arc, the iron became hard as a result of partial conversion to a crude silicon alloy. In another, a piece or iron, upon repeated dipping in a powdered "ore," heating, and cooling, developed a hard, lustrous surface. Undoubtedly case-hardening resulted from heating the iron in the forge in contact with coke that was protected from oxidation by a coating of slag formed by fusion of the powdered "ore." The same results were obtained by using a flux instead of the "ore." The surface of the metal specimen submitted by the sponsor of the process contained small pieces of adherent slag that were capable of scratching glass.

A claim that a coating of white metal was found on the outside of an iron ladle used to flux ore was investigated. The white metal proved to be slag.[10] Other claims that a white metal had "eaten" its way through an iron shovel and plated the edges of the resulting hole were studied.[11] The hole was caused by sulfides in the ores, which reacted with the iron of the shovel and made it brittle and by burning with the forge blast. The plating was the result of the cleansing action of the flux, which left the iron bright and silverlike.

CONCLUSION

To summarize, it may be said that all authentic tests have given results that may be adequately explained by the usual properties of the materials used. It must be concluded, therefore, that the various unsubstantial claims that have been made were due to careless tests, to erroneous interpretation of tests, or to an attempt to defraud. Although under certain favorable conditions it is possible to effect a hardening or alloying action or to extract metallic iron from some rocks, the difficulty of obtaining reproducible results and of controlling the composition of the alloy would make the practicability of such procedures doubtful. Well-known methods are available that can be exactly controlled.

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[10] Investigator, H. W. Young, metallurgist, Palo Alto, California (1925).

[11] A. S. Eakle, mineralogist, Berkeley, California.

MINE ASSESSMENT WORK SUSPENDED ON CLAIMS WITHIN WITHDRAWN AREAS

[Public Law 655—77th Congress]

[Chapter 486—2d Session]

[H. R. 6295]

AN ACT

To suspend the requirement for the performance of annual labor on certain mining claims.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That the provision of section 2324 of the Revised Statutes of the United States which requires that on each mining claim located after May 10, 1872, and until a patent has been issued therefor, not less than $100 worth of labor shall be performed or improvements made during each year, shall be suspended as to all valid mining claims in the United States, including the Territory of Alaska, which are situated within the exterior limits of any area withdrawn by Executive order for purposes of national defense, and such suspension shall remain in force and effect until the end of the assessment year during which the order of withdrawal is vacated by the President or by Act of Congress. Where it is found necessary to utilize the surface of valid mining claims for purposes of national defense, the record holders thereof are authorized to enter into agreements providing for such use with any executive department or Federal agency exercising control or jurisdiction over the land.

Approved, July 3, 1942.

ADMINISTRATIVE

Walter W. Bradley, State Mineralogist

Personnel

Effective February 1, 1942, Mr. J. C. O'Brien, acting district mining engineer in the Redding branch office was promoted from the grade of ''assistant mining engineer'' to that of ''district mining engineer.''

New Publications

CALIFORNIA JOURNAL OF MINES & GEOLOGY, July 1941, being Chapter 3 of State Mineralogist's Report XXXVII. This chapter contains: "Mineral Resources of Nevada County," accompanied by two maps, (1) showing the locations of mining claims in the county with a tabulated list of the names by townships (2) a larger-scale map of the Grass Valley-Nevada City district; and under Special Articles: "History of the names Cobalt and Nickel"; "Aluminum"; "Quartz"; "New Mining Laws"; also a Summary of the "Mineral Production of California for the year 1940."

COMMERCIAL MINERAL NOTES, (Nos. 223, 224, 225), November, December, 1941, and January, 1942, also Nos. 226-228, (inclusive), February, March, April, respectively, 1942. These 'Notes' contain the list of 'mineral deposits wanted' and 'mineral deposits for sale,' issued in the form of a mimeographed sheet monthly. It is mailed free to those on the mailing list for 'California Journal of Mines and Geology.' As an evidence of the interest in mines and mineral resources now showing considerable activity, this mimeographed 'sheet' has had to be expanded to five pages in recent months.

Mail and Files

The Division of Mines maintains, in addition to its correspondence files and the library, a mine file which includes original reports on the various mines and mineral properties of all kinds in California.

During each quarterly period there are several thousand letters received and answered at the San Francisco Office alone, covering almost every phase of prospecting, mining and developing mineral deposits, reduction problems, marketing of refined products and mining law. In addition to this, hundreds of oral questions are answered daily, both at the main office and the district offices, for the many inquirers who come in for personal interviews and to consult the files and library.

MINERALS AND STATISTICS

Statistics, Museum, Laboratory

Henry H. Symons, Statistician and Curator

Tabulations are presented herein showing the complete totals for all substances produced in California during the year 1941, grouped by substances and by counties. The complete detailed annual report on the mineral production of California for 1941 will be available later as Bulletin 122 of the State Division of Mines.

SUMMARY—1941

The total value of the mineral output for California for the year 1941 was $374,327,409, being an increase of $31,501,592 over the total for 1940 which was $342,825,817, the increase being due to stimulated outputs in production of petroleum, cement, miscellaneous stone, tungsten ore, quicksilver, natural gas, etc.

There were sixty-four different mineral substances including "gems" (varieties not segregated); and all fifty-eight counties of the State contributed one or more materials to the year's output.

As revealed by the following, salient features of 1941 as compared with the previous year were: All groups of mineral substances such as fuels, metals, structural materials, and industrial minerals showed increases in total value, with the exception of the salines which showed a decrease in total value. Of the year's mineral output cement showed the greatest increase in total value, followed in turn by petroleum, miscellaneous stone, tungsten ore, quicksilver, natural gas, brick and hollow building tile, pottery clay, diatomite, chromite, magnesite, gypsum, lead, magnesium salts, etc., and the greatest annual value for their output in California was recorded by gypsum, iron ore, lime, magnesium salts, pumice and volcanic ash, quicksilver, silica (glass sand and quartz), soapstone and talc, sulphur, and strontium minerals. Decreases in the annual production were shown by gold, potash, borates, copper soda, silver, salt, and limestone.

Of the fuels, petroleum showed an increase in value of $11,359,552, an increase in amount from 223,394,805 barrels to 229,665,435 barrels of crude oil. In March there were cuts in the prices paid for most grades of crudes with increases in April which in most cases were slightly higher than paid at the beginning of the year, after which there were no marked changes in crude prices. Natural gas showed increases in amount and value from 352,871,945 M. cu. ft. worth $20,618,893 to 378,173,737 M. cu. ft. worth $21,522,445.

Of the metals, the materials under this group showed increase in amount and value with the exception of gold, copper, silver, platinum group metals, and antimony. Quicksilver increased from 18,907 flasks worth $3,209,754 to 25,612 flasks worth $4,509,041, this being the largest annual value for this metal on record in this State. Tungsten ore increased from 107,022 units of WO_3 worth $2,267,135 to 171,672 units worth $4,080,628 and the largest production since 1916. The chromite output was the largest since 1918 and that of manganese ore the largest since 1919. The gold output decreased from a total value of $50,948,485 to $49,307,755. The quicksilver miners received the highest average annual price per flask ever paid in this State, which was $176,033.

Of the structural materials all substances listed under this grouping showed an increased annual value with the exception of bituminous rock and marble, these being practically the same as in 1940. The group increased in total value from $34,739,419 to $51,938,605 with cement increasing from 13,955,255 barrels worth $17,673,202 to 19,531,608 barrels worth $26,248,694, this being the largest annual output in amount, the value being passed only by that of 1927. Miscellaneous stone increased in total value from $12,181,574 to $19,559,883 and this annual value being passed by that of 1926. Brick and hollow building tile increased from a total of $2,762,885 to $3,598,797.

Distribution of the 1941 output of California by substances is shown in the following tabulation:

Substance	Amount	Value	Number of properties
Antimony ore	19,153 lbs.	$2,537	8
Bentonite	18,369 tons	164,582	8
Borates	224,986 tons	4,745,872	5
Brick and hollow building tile		3,598,797	37
Carbon dioxide	138,682 M cu. ft.	258,563	3
Cement	19,531,608 bbls.	26,248,694	12
Chromite	15,453 long tons	355,354	30
Clay (pottery)	551,347 tons	1,217,466	51
Copper	101,449 lbs.	955,970	e
Dolomite	22,300 tons	64,595	6
Gem material		870	5
Gold	1,408,793 fine ozs.	49,307,755	a
Granite		261,661	13
Gypsum	432,784 tons	854,184	12
Lead	6,900,851 lbs.	393,348	e
Lime	110,719 tons	996,514	20
Limestone	459,153 tons	801,868	
Magnesium salts	6,352 tons	654,372	3
Manganese ore	3,183 long tons	75,057	9
Marble[a]		14,448	4
Mineral water	17,746,256 gals.	988,520	38
Natural gas	378,173,737 M. cu. ft.	21,522,445	b
Petroleum	229,665,435 bbls.	218,839,352	
Platinum metals	909 fine ozs.	40,590	e
Pumice and volcanic ash	85,309 tons	283,663	17
Quicksilver	25,612 flasks	4,509,041	98
Salt	434,237 tons	1,180,929	12
Sandstone		13,143	9
Silica (quartz and glass sand)	137,660 tons	514,266	9
Silver	2,154,188 fine ozs.	1,531,867	e
Soapstone and talc	47,935 tons	525,396	11
Soda	179,210 tons	2,028,718	6
Stone, miscellaneous	34,626,035 tons	19,559,883	221
Sulphur	9,495 tons	209,296	3
Tungsten ore	171,672 units	4,080,628	24
Zinc	880,612 lbs.	66,046	e
Unapportioned[d]		7,461,119	
Total value		$374,327,409	

[a] There were 835 mines and 724 placer mines, not including snipers, prospectors, and various individuals who sold small lots.

[b] There was an average of 16,515 producing wells.

[c] Includes macadam, crushed rock, ballast, rubble, riprap, and sand and gravel.

[d] Includes asbestos (2), barite (3), bituminous rock (2), bromine (3), calcium chloride (2), calcium silicate (1), coal (1), diatomite (3), feldspar (2), iodine (2), iron ore (3), lithia (1), magnesite (5), mica (3), mineral paint (1), molybdenum (1), potash (1), pyrite (1), sillimanite group (2), slate (3), strontium (3), titanium (1), zircon (1), paving blocks (1), tubemill pebbles (3).

[e] Included with gold.

The industrial mineral group showed an increase in total value from $6,357,748 to $8,502,571, with gypsum, pumice and volcanic ash, silica, soapstone and talc, strontium, and sulphur reaching an all-time high in value of total annual output. The total value of the saline group decreased from $13,674,519 to $11,927,533, and with only one of the more important substances showing an increased value for the year, namely magnesium salts. The decreased value here did not indicate a lack of demand for the materials classified under this group but was brought about by one of the larger plants being shut down for several months by labor trouble.

Distribution by counties of the 1941 output for California, by substances, is shown in the following tabulation:

County	Value	Number of mineral products
Alameda	$4,447,145	8
Alpine	6,996	3
Amador	3,724,412	10
Butte	3,171,872	10
Calaveras	4,394,039	11
Colusa	41,859	4
Contra Costa	3,263,091	8
Del Norte	112,253	5
El Dorado	2,294,164	11
Fresno	23,751,031	15
Glenn	33,204	1
Humboldt	85,267	9
Imperial	578,808	17
Inyo	5,020,026	21
Kern	70,849,124	20
Kings	11,300,067	3
Lake	1,091,883	4
Lassen	39,322	5
Los Angeles	101,657,195	21
Madera	180,330	7
Marin	186,322	4
Mariposa	1,327,594	8
Mendocino	75,074	6
Merced	2,579,986	5
Modoc	125,427	5
Mono	544,547	8
Monterey	419,372	9
Napa	1,019,184	11
Nevada	10,255,176	7
Orange	19,399,481	14
Placer	1,759,591	13
Plumas	2,370,091	8
Riverside	6,351,012	13
Sacramento	7,484,001	13
San Benito	1,988,205	6
San Bernardino	16,953,033	31
San Diego	1,411,934	16
San Francisco	56,187	4
San Joaquin	1,832,622	7
San Luis Obispo	572,025	11
San Mateo	3,425,263	6
Santa Barbara	10,022,819	11
Santa Clara	5,832,080	10
Santa Cruz	3,260,828	9
Shasta	3,758,848	10
Sierra	964,347	6
Siskiyou	2,578,223	11
Solano	1,141,335	3
Sonoma	1,187,406	6
Stanislaus	1,325,932	9
Sutter	121,848	2
Tehama	2,925	1
Trinity	1,556,365	10
Tulare	272,661	9
Tuolumne	1,142,905	13
Ventura	21,432,573	9
Yolo	281,303	3
Yuba	3,265,986	5
Total value	$374,327,409	----------

MUSEUM

The Museum of the State Division of Mines possesses an exceptionally fine collection of rocks and minerals of both economic and academic value. It ranks among the first five of such collections in North America and contains not only specimens of most of the known minerals found in California, but much valuable and interesting material from other states and foreign countries as well.

The exhibit is daily visited by engineers, students, business men, and prospectors as well as tourists and mere sightseers. Besides its practical use in the economic development of California's mineral resources, the collection is a most valuable educational asset to the state and to San Francisco.

Mineral specimens suitable for exhibit purposes are solicited, and their donation will be appreciated by the State Division of Mines as well as by those who utilize the facilities of the collection.

Among the specimens received recently and catalogued for the Museum are the following:

21068 CASSITERITE (SnO_2), tin oxide. Locality: Portugal. Donor: R. E. Gruber. October, 1941. In case 118.

21069 CINNABAR in Chalcedony. Locality: Blue Bell Claim, New Idria District, San Benito County, California. Donor: E. D. Harnden. October, 1941. In case 224.

21070 TEKTITE—of meteoric origin. Locality: Grimes County, Texas. Secured on exchange with Dr. V. E. Barnes, University of Texas. November, 1941. In case 103.

21071 BEMENTITE, ($H_6Mn_5(SiO_4)_4$—hydrous manganese silicate. Locality: Near Cresent Lake, Olympic Peninsula, Clallam County, Washington. Donor: Erne W. Watson. November, 1941. In case 240.

21072 HAUSMANNITE, Mn_3O_4—an ore of manganese carrying as much as 57% Mn, and only 3.4% SiO_2 and 0.75% Fe. Locality: Near Crescent Lake, Olympic Peninsula, Clallam County, Washington. Donor: Erne W. Watson. November, 1941. In case 240.

21073 MOLYBDENITE (MoS_2), with SCHEELITE ($CaWO_4$) in garnetiferous gangue. Locality: Pine Creek Tungsten Mine, Inyo County, California. Donor: U. S. Vanadium Corp. per A. J. Link, Mine Sup't. November, 1941. In case 209.

21074 STOLZITE ($PbWO_4$), lead tungstate crystals, with associated CERUSITE ($PbCO_3$), lead carbonate. Locality: Darwin Lead-Silver Mine, Darwin, Inyo County, California. Donor: H. E. Olund. November, 1941. In case 150.

21075 Green MUSCOVITE with inclusions of SPESSARTITE Garnet. Locality: Mitchell County, Georgia. Donor: Mrs. J. Marshall Dearborn. November, 1941. In case 407.

21076 SCHEELITE with GARNET and CALCITE. Locality: On Kern River, four miles east of Havilah, Kern County, California. Donor: Ray Chalmers. November, 1941. In case 313.

21077 SCHEELITE with orthoclase feldspar in high-grade veinlets in impure limestone and tactite. Locality: Tungsten mine at Darwin, Inyo County, California. Donor: Arthur Sweet. December, 1941. In case 313.

21078 SCHEELITE in garnet and epidote gangue. Locality: Dakota Group (tungsten) Coso Mountains, five miles southeast of Darwin, Inyo County, California. Donor: Jack Stewart and Frank Terry. November, 1941. In case 313.

21079 TUNGSTITE, WO_3—Tungsten trioxide. Locality: Beaver County, Utah. Donor: Bessie Anderson. December, 1941. In case 313.

21080 SCHEELITE ($CaWO_4$), high grade, crystalline, veins in garnet gangue. Locality: Wolframite Mine, three miles north of Red Lake on Carson Pass road, Alpine County, California. Donor: F. Will Kuechler. February, 1942. In case 201.

21081 Leopard CHROMITE. Locality: Forest Hill, Placer County, California. Donor: Leonid Bryner. February, 1942. In case 302.

21082 BLÖDITE, $MgSO_4.Na_2SO_4.4H_2O$, a hydrous sodium and magnesium sulphate. Locality: Near Mecca, Riverside County, California. Donor: C. D. Adams. February, 1942. In case 149.

21083 CALCITE, twinning accentuated by a small amount of iron and manganese. Locality: East of Yermo, San Bernardino County, California. Donor: Major C. M. Jenni. February, 1942. In case 120.

21084 EMERALD (a variety of Beryl) in formation. Locality: Muzo Emerald Mine, Boyaca, Columbia, South America. Donor: W. T. Dinneen. March, 1942. In case 128.

21085 CALIFORNITE, a variety of Idocrase; in matrix of serpentine. Locality: Pulga, Butte County, California. Donor: C. H. Trester. March, 1942. In case 130.

21086 Calcarious Concretion. Locality: Panamint Valley, Inyo County, California. Donor: Eugene A. Bacchi. April, 1942. In case 504.

21087 SILICEOUS SINTER showing cast of earlier calcite crystals, coming from Jail Canyon, Panamint Range, Inyo County, California. Donor: Eugene A. Bacchi. April, 1942. In case 412.

21088 SCHEELITE ($CaWO_4$)—tan colored specks; with Quartz, Calcite, and Pyrite. Locality: Dean Vein, Washington Mine, French Gulch, Shasta County, California. By courtesy of the Company. April, 1942. In case 313.

21089 GOLD recovered from the beach near Fort Funston in city limits of San Francisco, California. Donor: S. A. Fetterley. May, 1942. In safe #2.

21090 GOLD Nugget in shape of an eagle, mounted on watch fob. Locality: Trinity County, California. Loaned by John Powers Hutchins. May, 1942. In safe #2.

21091 BRUCITE $Mg(OH)_2$, hydrous magnesium oxide; Blue (crystal, apparently secondary vein); White (massive). Locality: Gabb's Valley, 40 miles east of Luning, Nevada. Donor: H. A. Geisendorfer. May, 1942. In case 407.

21092 MAGNESIUM Metal. Locality: Permanente, Santa Clara County, California. Donor: John Finn. June, 1942. In case 802.

21093 MANGANESE ORE, content 55% Mn and 7% SiO_2. Locality: Aho Mine, Cazadero, California. Donor: Gene Aho. July, 1942. In case 234.

21094 CINNABAR (HgS). Locality: Alta Quicksilver Group, six miles northwest from Bodie at Millersville, Mono County, California. Donors: Warren Loose, Jr. and G. A. Peterson. July, 1942. In cases 107 and 217.

21095 Rock containing small crystals of RUTILE. Locality: 9 miles northwest of Barstow, San Bernardino County, California. Donor: Frederick Bense. July, 1942. In case 225.

21096 SCHEELITE. Locality: Isabella, Kern County, California. Donor: J. C. Roop. July, 1942. In case 313.

LABORATORY

George L. Gary, Mineral Technologist

Since 1866 many lists have been published showing localities of California minerals. The last one, ''Minerals of California,'' by Adolph Pabst, was published in 1938 by the Division of Mines as Bulletin No. 113.

It is the intention of the Division of Mines to publish in the quarterly new localities for minerals that are received by the laboratory for determination. So that this information may be accurate, it is requested that all specimens submitted for classification be accompanied by a letter giving the exact location where the material was found.

Corrections will also be noted as well as additions when called to our attention.

CORRECTIONS AND ADDITIONS TO BULLETIN 113

117. **Andalusite,** an aluminum silicate, Al_2SiO_5 was reported from Victorville, San Bernardino County.

118. **Correction:** Bulletin 113, p. 300, last word—on the last line should be Drum.

119. **Correction:** Bulletin 113, p. 40, 5th line under molybdenite—Fusible should be infusible.

120. **Thulite,** a pink variety of zoisite, a calcium-aluminum silicate occurs in bright pink crystals at Crestmore, Riverside County.

LIBRARY

Henry G. Hubbard, Librarian

In addition to the numerous standard works, authoritative information on many phases of the mining and mineral industry is constantly being issued in the form of reports and bulletins by various government agencies.

The library of the Division of Mines contains over six thousand selected volumes on mines, mining and allied subjects, and it is also a repository for reports and bulletins of the technical departments of Federal and State governments and of educational institutions, both domestic and foreign.

It is not the dearth of the latter publications, but rather a lack of knowledge of just what has been published and where the reports may be consulted or obtained, that embarrasses the ordinary person seeking specific information.

To assist in making the public acquainted with this valuable source of current technical information, California Journal of Mines and Geology contains under this heading a list of all books and official reports and bulletins received which pertain particularly to mining in California.

Files of all the leading technical journals will be found in the library, and county and State maps, topographical sheets and geological folios. Current copies of local newspapers published in the mining centers of the State are available for reference.

The library and reading room are open to the public during the usual office hours, when the librarian may be freely called upon for all necessary assistance.

OFFICIAL PUBLICATIONS RECEIVED WHICH HAVE SPECIAL INTEREST OR REFERENCE TO CALIFORNIA

Governmental, National

U. S. Geological Survey

Bulletins

- 931-B Some Quicksilver Prospects in Adjacent Parts of California, Nevada and Oregon.
- 931-E Tungsten Deposits in the Sierra Nevada near Bishop, California.
- 932-A Geophysical Abstracts, January-March, 1941.
- 914 (Correction Sheet) Microscopic Determination of the Ore Minerals.

Water Supply Papers

- 868-A Investigations of Methods and Equipment used in Stream Gaging (Part 1).
- 868-B Investigations (Part 2).
- 879 U. S. Surface Water Supply (Part 9) Colorado River Basin.

Topographic Maps

- Devore Quadrangle, San Bernardino County.
- Firebaugh Quadrangle, Fresno and Madera counties.
- Ontario and Vicinity Quadrangle, San Bernardino County.

Topographic Maps—Continued

Prado Quadrangle, San Bernardino, Riverside and Orange counties.
Gausti and Vicinity Quadrangle, San Bernardino and Riverside counties.
Swarthout Quadrangle, Los Angeles County.
Waterman Mountain Quadrangle, Los Angeles County.

Professional Paper

195 Geology of the Kettleman Hills Oil Field, California.

U. S. Bureau of Mines

Bulletins

431 Mechanical Concentration of Gases.
438 Quarry Accidents in the United States, 1939.
439 Some Essential Safety Factors in Tunneling.
440 Metal and Nonmetal Mine Accidents in the U. S., 1939.

Technical Papers

632 Theoretical calculations for explosives.

Report of Investigations

No. 3564; 3567; 3569; 3570, 3571; 3574; 3576; 3578; 3580; 3582-3584; 3589.

Information Circulars

6884-R; 7164; 7169-7174; 7177; 7179; 7182-7183.

U. S. Geological Survey

Bulletins, Water Supply Papers, Topographic Maps, Professional Papers.

U. S. Bureau of Mines

Bulletins, Technical Papers, Report of Investigations, Information Circulars, Miners Circulars.

PUBLICATIONS RECEIVED CURRENTLY AND FORMER REPORTS AVAILABLE FOR REFERENCE

Governmental, State

Alabama Geological Survey, University.
Alaska (Territorial Commissioner of Mines), Juneau
Arizona Bureau of Mines, Tucson.
Arkansas Geological Survey, Little Rock.
Colorado Bureau of Mines, Denver.
Connecticut Geological and Natural History Survey, Hartford.
Florida Department of Conservation, Tallahassee.
Georgia Division of Geology, Atlanta.
Idaho Bureau of Mines and Geology, Moscow.
Illinois Geological Survey, Urbana.
Indiana Division of Geology, Indianapolis.
Iowa Geological Survey, Des Moines.
State Geological Survey of Kansas, Lawrence.
Kentucky Geological Survey, Frankfort.
Louisiana Department of Conservation, New Orleans.
Maine State Geologist, Augusta.
Maryland Geological Survey, Baltimore.
Michigan Geological Survey, Lansing.
Minnesota Geological Survey, Minneapolis.
Mississippi State Geological Survey, University.
Missouri Bureau of Geology & Mines, Rolla.
Montana Bureau of Mines and Geology, Butte.
Nebraska Geological Survey, Lincoln.
Nevada State Bureau of Mines, Reno.
New Jersey Department of Conservation and Development, Trenton.
New Mexico Bureau of Mines and Mineral Resources, Socorro.
New York Science Division, Albany.
North Carolina Geological & Economic Survey, Chapel Hill.
North Dakota Geological Survey, Grand Forks.
Ohio Geological Survey, Columbus.

Oklahoma Geological Survey, Norman.
Oregon State Department of Geology and Mineral Industries, Portland.
Pennsylvania Topographic and Geological Survey, Harrisburg.
South Dakota State Geological Survey, Vermillion.
Tennessee Division of Geology, Nashville.
Texas Bureau of Economic Geology, Austin.
Virginia Geological Survey, University.
Washington State Department of Conservation and Development, Pullman.
West Virginia Geological Survey, Morgantown.
Wisconsin Geological & Natural History Survey, Madison.
Wyoming Geological Survey, Cheyenne.

Governmental, Foreign

Alberta Research Council, Edmonton.
Argentina Direccion General de Minas y Geologica, Buenos Aires.
British Columbia Minister of Mines, Victoria.
British Museum and Natural History, London.
Canada Department of Mines, Ottawa.
Cuerpo de Ingenieros de Minas y Aguas del Peru, Lima.
Geological Service of Minas Geraes, Bella Horizonte, Brazil.
Geological Survey of Scotland.
Instituto Historica e Geographico Rio de Janeiro.
Museo de Historia Natural de Montevideo, Uruguay.
New South Wales Department of Mines, Sydney, Australia.
New Zealand Geological Survey Branch, Wellington.
Nova Scotia Department of Public Works and Mines, Halifax.
Ontario Department of Mines, Toronto, Canada.
Quebec Bureau of Mines, Quebec.
Queensland Department of Mines, Brisbane, Australia.
South Australia Department of Mines, Adelaide.
Transvaal Chamber of Mines, Johannesburg, South Africa.
Western Australia Geological Survey, Perth.

Societies and Educational Institutions

Academia de Ciencias y Artes de Barcelona, Spain.
Academy of Natural Sciences of Philadelphia.
American Association of Petroleum Geologists, Tulsa, Oklahoma.
American Geographical Society of New York.
American Institute of Mining and Metallurgical Engineers, New York.
American Journal of Science, New Haven, Conn.
American Philosophical Society, Philadelphia.
Australian Museum, Sydney.
California Academy of Sciences, San Francisco.
Canadian Institute of Mining and Metallurgy, Montreal.
Carnegie Institution of Washington.
Cleveland Museum of Natural History, Cleveland, Ohio.
Colorado College Publications, Colorado Springs.
Colorado Scientific Society, Denver.
Commonwealth Club, San Francisco.
Economic Geology, Lancaster, Pa.
Field Museum of Natural History, Chicago.
Franklin Institute of the State of Pennsylvania, Lancaster.
Geological Society of America, Columbia University, New York.
Geographical Society of London.
Institution of Mining and Metallurgy, London.
Instituto Geologico de Mexico, Mexico, D. F.
Journal of Geology, Chicago.
Mineralogical Society of America, Menasha, Wisconsin.
Michigan College of Mining and Technology, Houghton.
Mining and Metallurgical Society of America, New York.
Missouri School of Mines and Metallurgy, Rolla.
Museu Nacional, Rio de Janeiro.
National Research Council, Washington, D. C.
New York Academy of Sciences, New York.

New York State Museum, Albany.
Pennsylvania State College, State College.
Philippine Journal of Science, Manila.
Royal Society of South Australia, Adelaide.
Seismological Society of America, Stanford University.
Sierra Club, San Francisco.
Society of Economical Paleontologists and Mineralogists, Fort Worth, Texas.
Southern California Academy of Sciences, Los Angeles.
Stanford University, Palo Alto, California.
University of California Publications in Engineering, Berkeley.
University of California Publications in Geography, Berkeley.
University of California Publications in Geology, Berkeley.
University of Harvard, Department of Mineralogy and Petrography, Cambridge, Mass.

Current Magazines on File

For the convenience of persons wishing to consult the technical magazines in the reading room, a list of those on file is appended:

Asbestos, Philadelphia, Pennsylvania.
Brick and Clay Record, Chicago.
California Journal of Development, San Francisco.
California Mining Journal, Auburn.
California Oil World, Los Angeles.
California Safety News, San Francisco.
Canadian Mining Journal, Gardenvale, Quebec.
Chemical and Metallurgical Engineering, New York City.
Chemical Engineering and Mining Review, Melbourne, Australia.
Civil Engineering, New York City.
Colorado School of Mines, Golden, Colorado.
Engineering and Mining Journal, New York City.
Fuel Oil, Chicago, Illinois.
Fusion Facts, Whittier, California.
Gold, Toronto, Canada.
Grizzly Bear, Los Angeles.
Hercules Mixer, Wilmington, Delaware.
Independent Monthly, Tulsa, Oklahoma.
Lubrication, The Texas Co., New York City.
Metals and Alloys, Pittsburgh, Pennsylvania.
Mine and Mill World Digest, San Francisco.
Mining and Contracting Review, Salt Lake City.
Mineralogist, Portland, Oregon.
Mining Congress Journal, Washington, D. C.
Mining and Industrial News, San Francisco.
Mining and Geological Journal, Melbourne, Victoria, Australia.
Mining Journal, London.
Mining Journal, Phoenix, Arizona.
Mining and Metallurgy, New York City.
Mining Review, Salt Lake City.
Mining World, Seattle.
Nevada Mining Bulletin, Las Vegas, Nevada.
Nickel Steel Topics, New York City.
Northwest Mining, Spokane, Washington.
Northwest Science, Cheney, Washington.
Oil and Gas Journal, Tulsa, Oklahoma.
Oil, Paint and Drug Reporter, New York City.
Oil Weekly, Houston, Texas.
Pacific Purchaser, San Francisco.
Pacific Chemical and Metallurgical Industries, San Francisco.
Petroleum World, Los Angeles.
Queensland Government Mining Journal, Brisbane, Australia.
Rock Products, Chicago.
Rocks and Minerals, Peekskill, New York.
Scientific American, New York City.

Southwest Builder and Contractor, Los Angeles.
Stabilizer, Los Angeles.
Standard Oil Bulletin, San Francisco.
Stone, New York City.
Western Mining News, San Francisco.

Newspapers

The following papers are received and kept on file in the library:

Alaska Weekly, Seattle, Washington.
Amador Dispatch, Jackson, California.
Banner, Sonora, California.
Barstow Printer, Barstow, California.
Bridgeport Chronicle-Union, Bridgeport, California.
Calaveras Californian, Angels Camp, California.
Calaveras Prospect, San Andreas, California.
Colusa Sun-Herald, Colusa, California.
Courier Free Press, Redding, California.
Daily Commercial News, San Francisco, California.
Del Norte Triplicate, Crescent City, California.
Denver Mining Record, Denver, Colorado.
Georgetown Gazette, Georgetown, California.
Humboldt Beacon, Humboldt.
Inyo Independent, Independence, California.
Inyo Register, Bishop, California.
Las Vegas Age, Las Vegas, Nevada.
Livermore Herald, Livermore, California.
Los Angeles Times, Los Angeles, California.
Mariposa Gazette, Mariposa, California.
Mercury Register, Oroville, California.
Mining Press, Reno, Nevada.
Mohave Miner, Kingman, Arizona.
Mojave-Randsburg Record, Mojave, California.
Morning Union, Grass Valley, California.
Mountain Messenger, Downieville, California.
Needles Nugget, Needles, California.
Nevada Mining Bulletin, Las Vegas, Nevada.
Oil Marketer, Bayonne, New Jersey.
Owens Valley Press-Citizen, Lone Pine, California.
Placer Herald, Auburn, California.
Placerville Times, Placerville, California.
Plumas Independent, Quincy, California.
Randsburg Times, Randsburg, California.
Shasta Courier, Redding, California.
Stockton Record, Stockton, California.
Tehachapi News, Tehachapi, California.
Terra Bella News, Terra Bella, California.
Tuolumne Independent, Sonora, California.
Tuolumne Prospector, Tuolumne, California.
Union Democrat, Sonora, California.
Ventura County News, Ventura, California.
Waterford News, Waterford, California.
Weekly Trinity Journal, Weaverville, California.
Western Mineral Survey, Salt Lake City, Utah.
Western Sentinel, Etna Mills, California.
Yreka Journal, Yreka, California.

New Books:

1. The Condensed Chemical Dictionary by Reinhold Publishing Corp. (1942).
2. Uranium and Atomic Power, by Dake & DeMent (1941).
3. Fluorescent Chemicals, by Jack DeMent (1942).
4. Mining Engineers Handbook (in 2 Vols.) by Robert Peele, 3rd Edition (1941).
5. The Mineral Industry During 1940, by C. A. Roush (1941).

PRODUCERS AND CONSUMERS

The producer and consumer of mineral products are mutually dependent upon each other for their prosperity, and one of the most direct aids rendered by this Division to the mining industry in the past has been that of bringing producers and consumers into direct touch with each other.

This work has been carried on largely by correspondence, supplemented by personal consultation. Lists of buyers of all the commercial minerals produced in California have been made available to producers upon request, and likewise the owners of undeveloped deposits of various minerals, and producers of them, have been made known to those looking for raw mineral products.

When the publication of *Mining in California* was on a monthly basis, current inquiries from buyers and sellers were summarized and lists of mineral products or deposits 'wanted' or 'for sale' included in each issue.

It is important that inquiries of this nature reach the mining public as soon as possible and in order to avoid the delay incident to the present quarterly publication of CALIFORNIA JOURNAL OF MINES AND GEOLOGY, these lists are now issued monthly in the form of a mimeographed sheet under the title of 'Commercial Mineral Notes,' and sent to those on the mailing list of CALIFORNIA JOURNAL OF MINES AND GEOLOGY.

EMPLOYMENT SERVICE

Following the establishment of the Mining Division branch offices in 1919, a free technical employment service was offered as a mutual aid to mine operators and technical men for the general benefit of the mineral industry.

Briefly summarized, men desiring positions are registered, the cards containing an outline of the applicant's qualifications, position wanted, salary desired, etc., and as notices of 'positions open' are received, the names and addresses of all applicants deemed qualified are sent to the prospective employer for direct negotiations.

Telephone and telegraphic communications are also given immediate attention.

Technical men, or those qualified for supervisory positions, and vacancies of like nature only, are registered, as no attempt will be made to supply common mine and mill labor.

Registration cards for the use of both prospective employers and employees may be obtained upon request, and a cordial invitation is extended to the industry to make free use of the facilities afforded. Parties interested should communicate direct with our San Francisco office.

Publications of the Division of Mines

PUBLICATIONS OF THE DIVISION OF MINES

During the past sixty-two years, in carrying out the provisions of the organic act creating the former California State Mining Bureau, there have been published many reports, bulletins and maps which go to make up a library of detailed information on the mineral industry of the State, a large part of which could not be duplicated from any other source.

One feature that has added to the popularity of the publications is that many of them have been distributed without cost to the public, and even the more elaborate ones have been sold at a price which barely covers the cost of printing.

Owing to the fact that funds for the advancing of the work of this department have usually been limited, the reports and bulletins mentioned are printed in limited editions many of which are now entirely exhausted.

Copies of such publications are available for reference, however, in the offices of the Division of Mines, in the Ferry Building, San Francisco; State Building, Los Angeles; State Office Building, Sacramento; Redding; and Division of Oil and Gas at Santa Barbara, Santa Paula, Taft, Bakersfield, Coalinga. They may also be found in many public, private and technical libraries in California and other states and foreign countries.

A catalog of all publications from 1880 to 1917, giving a synopsis of their contents, is issued as Bulletin No. 77.

Publications in stock may be obtained postpaid by addressing the San Francisco, Los Angeles or Sacramento offices and enclosing the requisite amount.

Remittances of stamps in an amount not to exceed 26 cents, currency or coin will be accepted at sender's risk. Payment is preferred in the form of money orders.

Money orders should be made payable to the Division of Mines.

NOTE.—The Division of Mines frequently receives requests for some of the early Reports and Bulletins now out of print, and it will be appreciated if parties having such publications and wishing to dispose of them will advise this office.

Write for latest revised price list.

REPORTS

Asterisks (**) indicate the publication is out of print.	Price (including postage and sales tax)
**First Annual Report of the State Mineralogist, 1880, 43 pp. Henry G. Hanks	----
**Second Annual Report of the State Mineralogist, 1882, 514 pp., 4 illustrations, 1 map. Henry G. Hanks	----
**Third Annual Report of the State Mineralogist, 1883, 111 pp., 21 illustrations. Henry G. Hanks	----
**Fourth Annual Report of the State Mineralogist, 1884, 410 pp., 7 illustrations. Henry G. Hanks	----
**Fifth Annual Report of the State Mineralogist, 1885, 234 pp., 15 illustrations, 1 geological map. Henry G. Hanks	----
Sixth Annual Report of the State Mineralogist, Part I, 1886, 145 pp., 3 illustrations, 1 map. Henry G. Hanks. Price $0.75, sales tax $0.02	$0.77
Part II, 1887, 222 pp., 36 illustrations. William Irelan, Jr. Price $0.75, sales tax $0.02	.77
**Seventh Annual Report of the State Mineralogist, 1887, 315 pp. William Irelan, Jr.	----
**Eighth Annual Report of the State Mineralogist, 1888, 948 pp., 122 illustrations. William Irelan, Jr.	----
**Ninth Annual Report of the State Mineralogist, 1889, 352 pp., 57 illustrations, 2 maps. William Irelan, Jr.	----
**Tenth Annual Report of the State Mineralogist, 1890, 983 pp., 179 illustrations, 10 maps. William Irelan, Jr.	----
Eleventh Report (First Biennial) of the State Mineralogist, for the two years ending September 15, 1892, 612 pp., 73 illustrations, 4 maps. William Irelan, Jr. Price $1.50, sales tax $0.05	1.55
**Twelfth Report (Second Biennial) of the State Mineralogist, for the two years ending September 15, 1894, 541 pp., 101 illustrations, 5 maps. J. J. Crawford	----
**Thirteenth Report (Third Biennial) of the State Mineralogist, for the two years ending September 15, 1896, 726 pp., 93 illustrations, 1 map. J. J. Crawford	----
Chapters of the State Mineralogist's Report, XIV Biennial Period, 1913-1914, Fletcher Hamilton:	
**Mines and Mineral Resources, Amador, Calaveras and Tuolumne Counties, 172 pp., paper	----
Mines and Mineral Resources, Colusa, Glenn, Lake, Marin, Napa, Solano, Sonoma and Yolo Counties, 208 pp., paper. Price $0.75, sales tax $0.02	.77
**Mines and Mineral Resources, Del Norte, Humboldt and Mendocino Counties, 59 pp., paper	----
**Mines and Mineral Resources, Fresno, Kern, Kings, Madera, Mariposa, Merced, San Joaquin and Stanislaus Counties, 220 pp., paper	----
**Mines and Mineral Resources of Imperial and San Diego Counties, 113 pp., paper	----
**Mines and Mineral Resources, Shasta, Siskiyou and Trinity Counties, 180 pp., paper	----
**Fourteenth Report of the State Mineralogist, for the Biennial Period 1913-1914, Fletcher Hamilton, 1915: A General Report on the Mines and Mineral Resources of Amador, Calaveras, Tuolumne, Colusa, Glenn, Lake, Marin, Napa, Solano, Sonoma, Yolo, Del Norte, Humboldt, Mendocino, Fresno, Kern, Kings, Madera, Mariposa, Merced, San Joaquin, Stanislaus, San Diego, Imperial, Shasta, Siskiyou and Trinity Counties, 974 pp., 275 illustrations, cloth	----
Chapters of the State Mineralogist's Report, XV Biennial Period, 1915-1916, Fletcher Hamilton:	
**Mines and Mineral Resources, Alpine, Inyo and Mono Counties, 176 pp., paper	----
Mines and Mineral Resources, Butte, Lassen, Modoc, Sutter and Tehama Counties, 91 pp., paper. Price $0.75, sales tax $0.02	.77

REPORTS—Continued

Asterisks (**) indicate the publication is out of print.	Price (including postage and sales tax)
Mines and Mineral Resources, El Dorado, Placer, Sacramento and Yuba Counties, 198 pp., paper. Price $0.75, sales tax $0.02	$0.77
Mines and Mineral Resources, Monterey, San Benito, San Luis Obispo, Santa Barbara and Ventura Counties, 183 pp., paper. Price $0.75, sales tax $0.02	.77
**Mines and Mineral Resources, Los Angeles, Orange and Riverside Counties, 136 pp., paper	----
**Mines and Mineral Resources, San Bernardino and Tulare Counties, 186 pp., paper	----
**Fifteenth Report of the State Mineralogist, for the Biennial Period 1915-1916, Fletcher Hamilton, 1917: A General Report on the Mines and Mineral Resources of Alpine, Inyo, Mono, Butte, Lassen, Modoc, Sutter, Tehama, Placer, Sacramento, Yuba, Los Angeles, Orange, Riverside, San Benito, San Luis Obispo, Santa Barbara, Ventura, San Bernardino and Tulare Counties, 990 pp., 413 illustrations, cloth	----
Chapters of the State Mineralogist's Report XVI, Biennial Period, 1917-1918, Fletcher Hamilton:	
Mines and Mineral Resources of Nevada County, 270 pp., paper. Price $1.00, sales tax $0.03	1.03
Mines and Mineral Resources of Plumas County, 188 pp., paper. Price $0.75, sales tax $0.02	.77
Mines and Mineral Resources of Sierra County, 144 pp., paper. Price $0.75, sales tax $0.02	.77
Seventeenth Report of the State Mineralogist, 1920, 'Mining in California during 1920,' Fletcher Hamilton; 562 pp., 71 illustrations, cloth. Price $2.50, sales tax $0.08	2.58
Eighteenth Report of the State Mineralogist, 1922, 'Mining in California,' Fletcher Hamilton. Chapters published monthly beginning with January, 1922:	
**January, **February, **March, **April, May, June, July, August, September, October, November, December, 1922. Price $0.40, sales tax $0.01	.41
Chapters of Nineteenth Report of the State Mineralogist, 'Mining in California,' Fletcher Hamilton and Lloyd L. Root. January, February, March, September, 1923. Price $0.40, sales tax $0.01	.41
Chapters of Twentieth Report of the State Mineralogist, 'Mining in California,' Lloyd L. Root. Published quarterly. January, April, July, October, 1924, per copy. Price $0.40, sales tax $0.01	.41
Chapters of Twenty-first Report of the State Mineralogist, 'Mining in California,' Lloyd L. Root. Published quarterly:	
January, 1925, Mines and Mineral Resources of Sacramento, Monterey and Orange Counties. Price $0.40, sales tax $0.01	.41
April, 1925, Mines and Mineral Resources of Calaveras, Merced, San Joaquin, Stanislaus and Ventura Counties. Price $0.40, sales tax $0.01	.41
**July, 1925, Mines and Mineral Resources of Del Norte, Humboldt and San Diego Counties	----
**October, 1925, Mines and Mineral Resources of Siskiyou, San Luis Obispo and Santa Barbara Counties	----
Chapters of Twenty-second Report of the State Mineralogist, 'Mining in California,' Lloyd L. Root. Published quarterly:	
**January, 1926, Mines and Mineral Resources of Trinity and Santa Cruz Counties	----
April, 1926, Mines and Mineral Resources of Shasta, San Benito and Imperial Counties. Price $0.40, sales tax $0.01	.41
July, 1926, Mines and Mineral Resources of Marin and Sonoma Counties. Price $0.40, sales tax $0.01	.41
**October, 1926, Mines and Mineral Resources of El Dorado and Inyo Counties, also report on Minaret District, Madera County	----

REPORTS—Continued

Asterisks (**) indicate the publication is out of print.	Price (including postage and sales tax)
Chapters of Twenty-third Report of the State Mineralogist, 'Mining in California,' Lloyd L. Root. Published quarterly:	
January, 1927, Mines and Mineral Resources of Contra Costa County; Santa Catalina Island Price $0.40, sales tax $0.01	$0.41
April, 1927, Mines and Mineral Resources of Amador and Solano Counties Price $0.40, sales tax $0.01	.41
**July, 1927, Mines and Mineral Resources of Placer and Los Angeles Counties	----
October, 1927, Mines and Mineral Resources of Mono County Price $0.40, sales tax $0.01	.41
Chapters of Twenty-fourth Report of the State Mineralogist, 'Mining in California,' Lloyd L. Root. Published quarterly:	
January, 1928, Mines and Mineral Resources of Tuolumne County Price $0.40, sales tax $0.01	.41
April, 1928, Mines and Mineral Resources of Mariposa County Price $0.40, sales tax $0.01	.41
**July, 1928, Mines and Mineral Resources of Butte and Tehama Counties	----
October, 1928, Mines and Mineral Resources of Plumas and Madera Counties Price $0.40, sales tax $0.01	.41
Chapters of Twenty-fifth Report of the State Mineralogist, 'Mining in California,' Walter W. Bradley. Published quarterly:	
**January, 1929, Mines and Mineral Resources of Lassen, Modoc and Kern Counties; also on Special Placer Machines	----
**April, 1929, Mines and Mineral Resources of Sierra, Napa, San Francisco and San Mateo Counties	----
July, 1929, Mines and Mineral Resources of Colusa, Fresno and Lake Counties Price $0.40, sales tax $0.01	.41
October, 1929, Mines and Mineral Resources of Glenn, Alameda, Mendocino and Riverside Counties Price $0.40, sales tax $0.01	.41
Chapters of Twenty-sixth Report of the State Mineralogist, 'Mining in California,' Walter W. Bradley. Published quarterly:	
January, 1930, Mines and Mineral Resources of Santa Clara County; also Barite in California Price $0.40, sales tax $0.01	.41
**April, 1930, Mines and Mineral Resources of Nevada County; also Mineral Paint Materials in California	----
**July, 1930, Mines and Mineral Resources of Yuba and San Bernardino Counties; also Commercial Grinding Plants in California	----
October, 1930, Mines and Mineral Resources of Butte, Kings and Tulare Counties: also Geology of Southwestern Mono County (Preliminary) Price $0.40, sales tax $0.01	.41
Chapters of Twenty-seventh Report of the State Mineralogist, 'Mining in California,' Walter W. Bradley. Published quarterly:	
January, 1931. Preliminary Report of Economic Geology of the Shasta Quadrangle. Beryllium and Beryl. The New Tariff and Nonmetallic Products. Crystalline Talc. Decorative Effects in Concrete Price $0.40, sales tax $0.01	.41
April, 1931, Stratigraphy of the Kreyenhagen Shale. Diatoms and Silicoflagellates of the Kreyenhagen Shale. Foraminifera of the Kreyenhagen Shale. Geology of Santa Cruz Island Price $0.40, sales tax $0.01	.41
**July, 1931. (Yuba, San Bernardino.) Feldspar, Silica, Andalusite and Cyanide Deposits of California. Note on a Deposit of Andalusite in Mono County; its occurrence and chemical importance. Bill creating Trinity and Klamath River Fish and Game District and its effect upon mining	----
October, 1931. (Alpine.) Geology of the San Jacinto Quadrangle south of San Gorgonio Pass, California. Notes on Mining Activities in Inyo and Mono Counties in July, 1931 Price $0.40, sales tax $0.01	.41
Chapters of Twenty-eighth Report of the State Mineralogist, 'Mining in California,' Walter W. Bradley. Published quarterly:	

REPORTS—Continued

Asterisks (**) indicate the publication is out of print.

	Price (including postage and sales tax)
January, 1932, Economic Mineral Deposits of the San Jacinto Quadrangle. Geology and Physical Properties of Building Stone from Carmel Valley. Contributions to the Study of Sediments. Sediments of Monterey Bay. Sanbornite____________Price $0.40, sales tax $0.01	$0.41
**April, 1932. Elementary Placer Mining Methods and Gold Saving Devices. The Pan, Rocker and Sluice Box. Prospecting for Vein Deposits. Bibliography of Placer Mining________________________	----
Abstract from April quarterly: Elementary Placer Mining Methods and Gold Saving Devices. Types of Deposits, Simple Equipment. Special Machines. Dry Washing. Black Sand Treatment. Marketing of Products. Placer Mining Areas. Laws. Prospecting for Quartz Veins. Bibliography (mimeographed)__________Free, postage $0.05	.05
**July-October, (Ventura.) Report accompaning Geologic Map of Northern Sierra Nevada. Fossil Plants in Auriferous Gravels of the Sierra Nevada. Glacial and Associated Stream Deposits of the Sierra Nevada. Jurassic and Cretaceous Divisions in the Knoxville-Shasta Succession of California. Geology of a part of the Panamint Range. Economic Report of a Part of the Panamint Range. Acquiring Mining Claims Through Tax Title. The Biennial Report of State Mineralogist ____	----
Chapters of Report XXIX, 1933 (quarterly): titled 'California Journal of Mines and Geology,' containing the following:	
January-April. Gold Deposits of the Redding and Weaverville Quadrangles. Geologic Formations of the Redding-Weaverville District, Northern California. Geology of Portions of Del Norte and Siskiyou Counties. Applications of Geology to Civil Engineering. The Lakes of California. Discovery of Piedmontite in the Sierra Nevada. Tracing 'Buried River' Channel Deposits by Geomagnetic Methods. Geologic Map of Redding-Weaverville District, showing gold mines and prospects. Geologic map showing various mines and prospects of part of Del Norte and Siskiyou Counties________________________ Price $1.00, sales tax $0.03	1.03
July-October. Gold Resources of Kern County. Limestone Deposits of the San Francisco Region. Limestone Weathering and Plant Associations of the San Francisco Region. Booming, Death Valley National Monument, California. Placer Mining Districts, Senate Bill 480. Navigable Waters, Assembly Bill 1543________________ Price $1.00, sales tax $0.03	1.03
Chapters of Report XXX, 1934 (quarterly): titled 'California Journal of Mines and Geology,' containing the following:	
January. Resurrection of Early Surfaces in the Sierra Nevada. Geology and Mineral Resources of Northeastern Madera County. Geology and Mineral Deposits of Laurel and Convict Basins, Southwestern Mono County. Notes on Sampling as Applied to Gold Quartz Deposits___ Price $0.60, sales tax $0.02	.62
April-July. Elementary Placer Mining in California and Notes on the Milling of Gold Ores_________________Price $1.00, sales tax $0.03	1.03
**October. Current Mining Developments in Northern California. Current Mining Activity in Southern California. Geology and Mineral Resources of the Julian District, San Diego County. Geology and Mineral Resources of Elizabeth Lake Quadrangle. Dry Placers of Northern Mojave Desert. Biennial Report of State Mineralogist. Assessment Work Within Withdrawn Areas______________________	----
Chapters of Report XXXI, 1935 (quarterly): titled 'California Journal of Mines and Geology,' containing the following:	
January. Review of Gold Mining in East-Central, 1934. Current Mining Activities in the San Francisco District with Special Reference to Gold. Geological Investigation of the Clays of Riverside and Orange Counties, Southern California. Information regarding Mining Loans by the Reconstruction Finance Corporation_____________ Price $0.60, sales tax $0.02	.62

REPORTS—Continued

Asterisks (**) indicate the publication is out of print.	Price (including postage and sales tax)
April. A Geologic Section Across the Southern Peninsular Range of California. New Technique Applicable to the Study of Placers. **Grubstake Permits** — Price $0.60, sales tax $0.02	$0.62
July. Mines and Mineral Resources of Siskiyou County (with map). Dams for Hydraulic Mining Debris. Leasing System as Applied to Metal Mining. Mine Financing in California. New Laws Make Radical Change in Mining Rights — Price $0.60, sales tax $0.02	.62
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**Map of Madera County, Showing Boundaries, National Forests	----
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**Map of Shasta County, Showing Boundaries, National Forests	----
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**Map of Siskiyou County, Showing Boundaries, National Forests	----
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March 1, 1941.

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Samples (limited to two at one time) of any mineral found in the State may be sent to the Division of Mines for identification, and the same will be classified free of charge. No samples will be determined if received from points outside the State. It must be understood that no assays, or quantitative determinations will be made. Samples should be in lump form if possible, and marked plainly with name of sender on outside of package, etc. No samples will be received unless delivery charges are prepaid. A letter should accompany sample, giving locality where mineral was found and the nature of the information desired.

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STATE OF CALIFORNIA
DEPARTMENT OF NATURAL RESOURCES
KENNETH I. FULTON, Director

DIVISION OF MINES
FERRY BUILDING, SAN FRANCISCO

WALTER W. BRADLEY State Mineralogist

Vol. 38 JULY and OCTOBER, 1942 Nos. 3 and 4

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OF

MINES AND GEOLOGY

QUARTERLY CHAPTERS
OF
STATE MINERALOGIST'S REPORT XXXVIII

STATE DIVISION OF MINES
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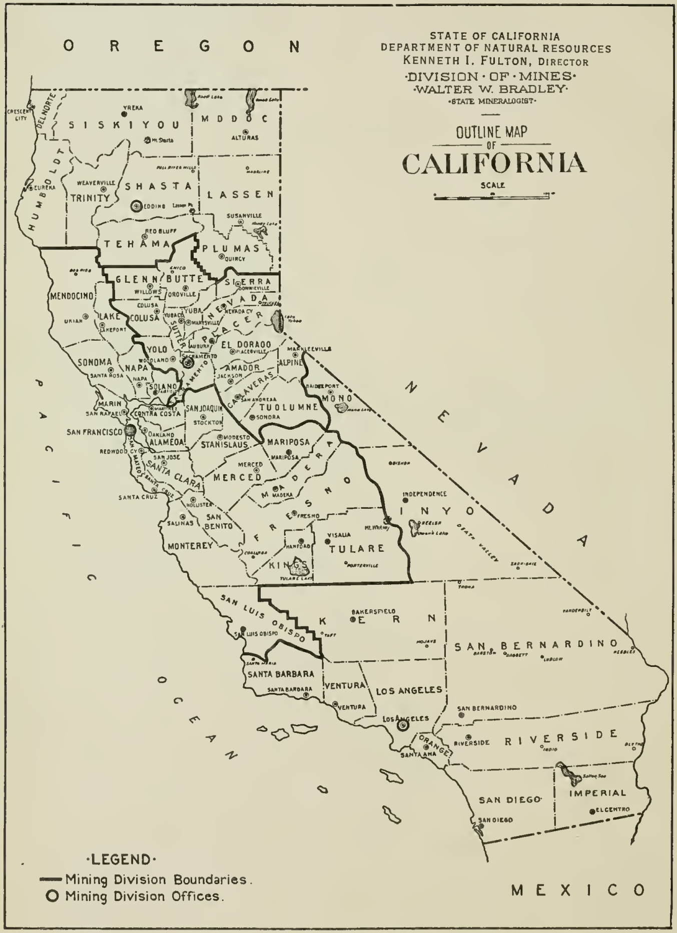

STATE OF CALIFORNIA
DEPARTMENT OF NATURAL RESOURCES
KENNETH I. FULTON, DIRECTOR
·DIVISION · OF · MINES·
·WALTER W. BRADLEY·
·STATE MINERALOGIST·

OUTLINE MAP
OF
CALIFORNIA

SCALE

·LEGEND·
Mining Division Boundaries.
O Mining Division Offices.

PREFACE

The Division of Mines (formerly State Mining Bureau) is maintained for the purpose of assisting in all possible ways in the development of California's mineral resources.

As one means of offering tangible service to the mining public, the State Mineralogist for many years has issued an annual or a biennial report reviewing in detail the mines and mineral deposits of the various counties.

As a progressive step in advancing the interests of the mineral industry, and as permitting earlier distribution to the public, publication of the Annual Report of the State Mineralogist in the form of monthly chapters was begun in January, 1922, and continued until March, 1923. Owing to a lack of funds for printing this was changed to a quarterly publication, beginning in September, 1923. For the same reason, beginning with the January, 1924, issue, it became necessary to charge a subscription price. This covers approximately the cost of printing.

Pages are numbered consecutively throughout the year and an index to the complete report is included annually in the closing number.

Beginning with the 1930 issues, the activities and progress of the Geologic Branch are recorded also in these quarterly chapters. The important part that geology plays in the economic development of our mineral resources is further recognized in the change of title from *Mining in California* to CALIFORNIA JOURNAL OF MINES AND GEOLOGY, beginning with the January, 1933, chapter.

While current activities of all descriptions are covered in these chapters, the practice of issuing from time to time technical reports on special subjects will be continued as well. A list of such reports now available is appended hereto, and the names of new bulletins will be added in the future as they are completed.

The chapters are subject to revision, correction and improvement. Constructive suggestions from the mining public will be gladly received, and are invited.

The one aim of the Division of Mines is to increase its usefulness and to stimulate the intelligent development of the wonderful, latent resources of the State of California.

Types of Reports

In general the reports presented in these chapters are grouped into three classes:

1. Mines and mineral resources of a given county or area (describing kind, character, distribution and extent of development).

2. Specific economic and industrial mineral products (listing and describing the resources over the entire state of a given mineral substance, e.g., feldspar).

3. Geological reports on specific areas (recording results and conclusions with maps, derived from field studies; and tied in with economic possibilities and developments).

REPORTS OF DISTRICT MINING ENGINEERS

In 1919–1920 the Mining Bureau was organized into four main geographical divisions, with the field work delegated to a mining engineer in each district, working out from field offices that were established in Redding, Auburn, San Francisco and Los Angeles, respectively. This move brought the office into closer personal contact with operators, and it has many advantages over former methods of conducting field work, including lower traveling-expense bills for the Bureau's engineers. In 1923 the Redding and Auburn field offices were consolidated and moved to Sacramento.

The Redding office was reestablished in 1928, and the boundaries of each district adjusted. The counties now included in each of the four divisions and the locations of the branch offices are shown on the accompanying outline map of the State. (Frontispiece.)

Reports of mining activities and development in each district, prepared by the District Engineer, will continue to appear under the proper field division heading.

GEOLOGIC BRANCH

CURRENT NOTES

By Olaf P. Jenkins, Chief Geologist

In This Issue

Doctor H. J. Fraser, Professor of Economic Geology, California Institute of Technology, together with two graduate students, H. D. B. Wilson and N. W. Hendry, has presented in this issue the results of a careful field and analytical study of the famous ''Hot springs deposits of the Coso Mountains.'' One of the significant features of this contribution is that the description deals with the actual processes of near-surface mineral deposition which are at work today, especially as regards quicksilver.

The ancient and deep-seated geologic processes which have been instrumental in the deposition of tungsten in the form of the mineral scheelite, are ably described in this issue by Mr. Charles W. Chesterman. The area of investigation lies in the heart of the Sierra Nevada, and involves the study of a ''roof pendant'' of crystalline marble, deeply engulfed in the granite batholith.

The three following papers contributed by Mr. James M. Little describe typical scheelite-bearing tactite bodies of the Sierra Nevada. The mapping by Mr. Little shows clearly the relationship of the deposits to the enclosing rocks.

A summary of all the known deposits of tungsten in California is presented in this issue in the form of a tabulation. This accompanies ''Economic Mineral Map No. 4, Tungsten,'' which represents one of a series of State mineral maps the author is preparing as companions to the ''Geologic Map of California'' of 1938.

In Preparation

A bulletin on the manganese resources and geology of California is forthcoming. Accompanying it will be ''Economic Mineral Map No. 5, Managanese.'' There will be several contributors to this bulletin, and it will represent a summary of the results of many years of careful research.

HOT SPRINGS DEPOSITS OF THE COSO MOUNTAINS *

By H. J. Fraser, H. D. B. Wilson, and N. W. Hendry

OUTLINE OF REPORT

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INTRODUCTION

The Coso Hot Springs region is located in the central part of the Coso Mountains, California. Knowledge of the hot springs predates early California mining days; use of the springs for medical purposes continues to the present day. The existence of mercury minerals in the solfataric altered zones was discovered in the early 1920's and led to considerable exploration and some mining in two major areas southwest of the village of Coso Hot Springs. The settlement, located in T. 22 S., R. 39 E., M. D., Inyo County, about 11 miles northeast of Coso Junction, a station on the Southern Pacific Railroad, can be reached by either of two graded gravel roads which run easterly from Highway 395. Coso Junction lies about 2 miles north of Little Lake.

Early reconnaissance work was done in the Coso Mountains by Fairbanks,[1] Gilbert,[2] and Spurr.[3] The cinnabar deposits have been described by Warner [4] and reviewed more recently by Ransome and Kellogg.[5]

The district surrounding the hot springs is one of relatively recent volcanic activity. Many fumaroles are still active. Active leaching and alteration of the wall rocks is in progress and native sulphur, iron, and aluminum sulphates, and possibly cinnabar are still being deposited. The area presents an interesting example of intense solfataric alteration in siliceous rocks.

---

* Contribution No. 336, Balch Graduate School of the Geological Sciences, California Institute of Technology, Pasadena, California. Manuscript submitted for publication June 1, 1942.

[1] Fairbanks, H. W., The mineral deposits of eastern California: Am. Geologist, vol. 17, pp. 144-158, 1896.
Fairbanks, H. W., Geology of California: Am. Geologist, vol. 17, pp. 63-76, 1896.

[2] Gilbert, G. K., Report on the geology of portions of Nevada, Utah, California, and Arizona: U S. Geog. and Geol. Surveys W. 100th Mer. Rept., vol 3, p. 124, 1875.

[3] Spurr, J. E., Descriptive geology of Nevada south of the fortieth parallel and adjacent portions of California: U S. Geol. Survey Bull. 208, 229 pp., 1903.

[4] Warner, Thor, Mercury deposit in Coso Range, Inyo County, California: California Dept. Nat. Resources, Div. Mines, State Mineralogist's Rept. 26, pp. 59-63, 1930.

[5] Ransome, A. L., and Kellogg, J. L., Quicksilver resources of California: California Dept. Nat. Resources, Div. Mines, California Jour. Mines and Geology, State Mineralogist's Rept. 35, pp. 378-380, 1939.

Elevations in the Coso Mountains vary from an average of 3,700 feet in Owen's Valley to a maximum of 8,156 feet at the summit of Coso Peak. Elevations in the area mapped and discussed herein vary from a minimum of 3,635 feet at Coso Hot Springs to a maximum of about 4,700 feet.

GENERAL GEOLOGY

The central part of Coso Mountains is composed of very coarse-grained granitic rock. Areas of diorite, hornblende gabbro, and other basic rocks occur in the granite, some as gneissic or schistose zenoliths, others as elongated dike-like masses which apparently intruded the granite. Lying upon the deeply weathered and eroded surface of the granite basement are a number of alluvial fans, best seen along the western flank of the range but also present along the northern and northeastern borders. The southern part is covered in many places by extensive but relatively thin beds of well-stratified tuff and volcanic breccia. The tuff, breccia, and alluvium all dip away from the crest of the range at low angles ranging between 6 and 10 degrees. Above the tuffs and conformable with them is a basaltic lava 50 to 100 feet thick. Associated with this lava in places are partially preserved basaltic cinder cones. Subsequently there were extensive flows of rhyolitic material; well-formed rhyolitic cinder cones may be seen along a north-south line about 3 miles west of Coso Hot Springs. In places these late rhyolite flows are covered with a shallow mantle of ash and volcanic tuff, some of which is unconsolidated, but in other places it is cemented by fine-grained silica.

Coso hot springs are situated in Coso basin, which covers approximately one square mile and is bounded by faults on the east and west sides. The entire region has undergone repeated faulting, the later stages of which are clearly shown in the basalt flows east of Coso basin. The basin, which is filled with tuff and alluvium, is bounded on the west and north by granite, and on the northeast, east, and southeast by basalt.

According to Schultz,[6] the later geological history of Coso Mountains may be summarized as follows:

1. Faulting or possibly warping which elevated the granitic core and made possible the accumulation of alluvial fan material to a depth of at least 300 feet. This material is now preserved mainly along the western and northern margins of the range.
2. Explosive volcanic activity with subsequent deposition of substantial thickness of tuffaceous material largely deposited in standing water.
3. Extensive outflows of basalt which covered the sediments.
4. Normal faulting followed by active erosion.
5. A renewal of volcanic activity and the extrusion first of basaltic flows, particularly around Little Lake, and later rhyolitic material, ash and tuff.

On the basis of some vertebrate fossils found in the sediments underlying the older tuff beds, Schultz [7] dated these sediments as transitional between lower and upper Pliocene. Consequently all of the volcanic activity is later than upper Pliocene and some undoubtedly belongs in the late Pleistocene or Recent.

---

[6] Schultz, J. R., A late Cenozoic vertebrate fauna from the Coso Mountains, Inyo County, California: Carnegie Inst., Washington Pub., no. 487, p. 80, 1937.

[7] *Op. cit.,* p. 98.

DIVISION OF MINES
WALTER W. BRADLEY, STATE MINERALOGIST
OLAF P. JENKINS CHIEF GEOLOGIST

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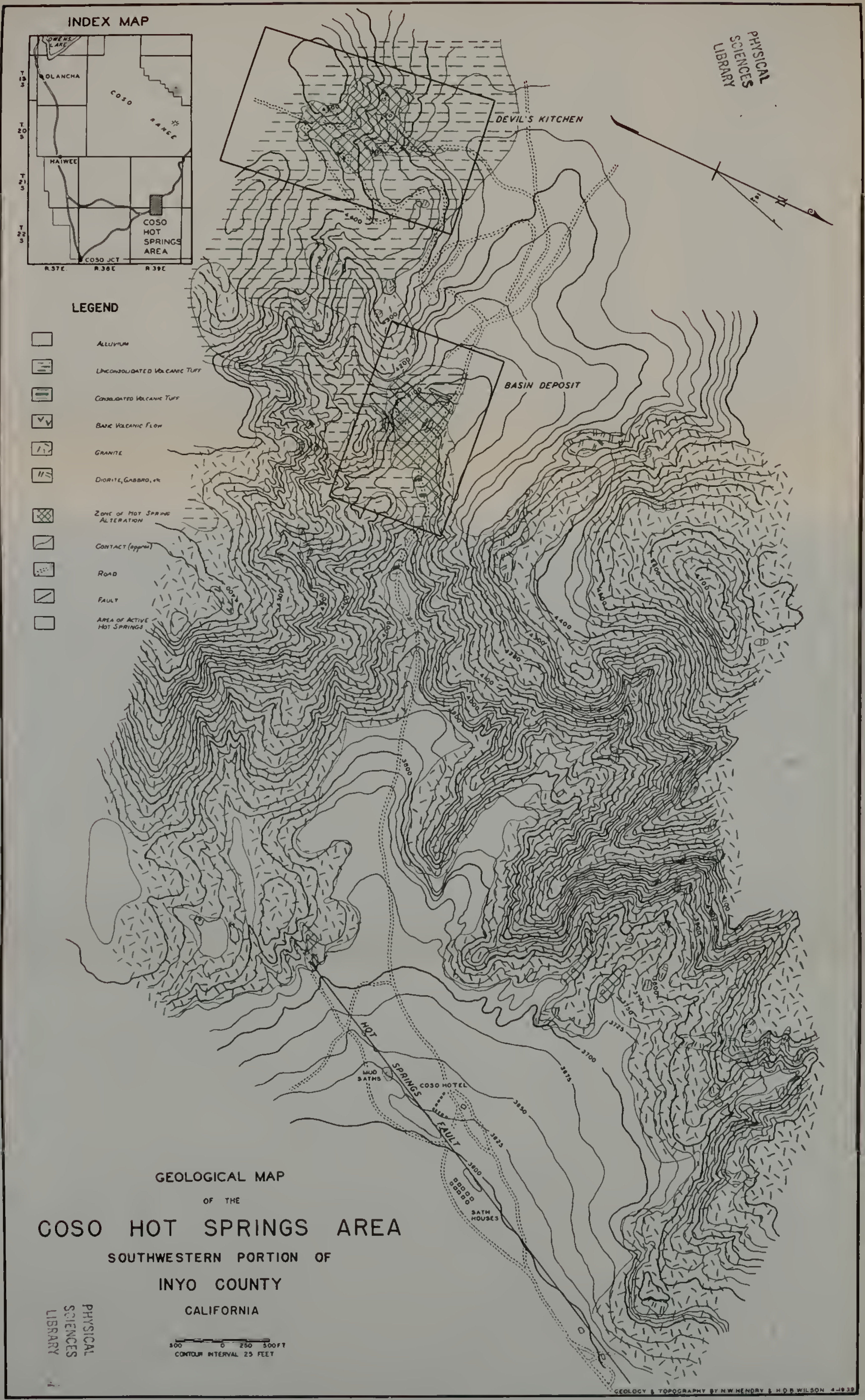

LEGEND

- Alluvium
- Unconsolidated Volcanic Tuff
- Consolidated Volcanic Tuff
- Basic Volcanic Flow
- Granite
- Diorite, Gabbro, etc.
- Zone of Hot Spring Alteration
- Contact (approx.)
- Road
- Fault
- Area of Active Hot Springs

GEOLOGICAL MAP
OF THE
COSO HOT SPRINGS AREA
SOUTHWESTERN PORTION OF
INYO COUNTY
CALIFORNIA

500 0 250 500 FT
CONTOUR INTERVAL 25 FEET

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GEOLOGY & TOPOGRAPHY BY N.W. HENDRY & H.D.B. WILSON 4-1939

ACCOMPANYING STATE MINERALOGIST'S REPORT XXXVIII, JULY—OCTOBER, 1942

The geology in the vicinity of the springs is shown on Plate IV. About two-thirds of the area is occupied by granite, the remainder is covered by tuff and alluvium. Areas of intense solfataric activity are scattered throughout the region; the more conspicuous of these are named "Devil's Kitchen," "Basin Deposit," "Coso Hot Springs," and "Coso Basin Deposit." The position of these and other minor areas of solfataric activity is indicated on the accompanying map with the exception of Coso Basin Deposit which lies about 2 miles south of Coso Hot Springs.

PETROLOGY

The typical granite of Coso Mountains is coarse, light-colored, and homogeneous in composition and texture. Away from solfataric areas the rock is relatively unaltered but disintegrates readily on weathering. It is cut by numerous aplitic dikes composed of approximately 40 percent quartz, 30 percent orthoclase, 25 percent albite, 5 percent microcline, and minor amounts of biotite, apatite, and magnetite. The feldspar of the aplite may be slightly altered to kaolin and sericite. The other constituents are unaltered.

Hornblende-gabbro inclusions in the granite are roughly circular in shape and range from 20 to 75 feet in diameter. They are most numerous in the vicinity of Devil's Kitchen. Locally they are characterized by hornblende crystals one inch or more in length and inclosing a fine-grained, greenish to light-gray groundmass. The composition of this gabbro is approximately 42 percent hornblende, 28 percent augite, 25 percent labradorite, together with accessory apatite, titanite, magnetite, and zircon. The hornblende is moderately fresh in appearance, although altered to chlorite along the margins, but the labradorite is considerably altered to epidote, zoisite, and sericite. In many places the rock has obviously undergone extensive recrystallization.

The inclusions of diorite material in the granite range from elongated slivers 1,000 by 50 feet to small roughly circular masses 50 feet or less in diameter. In the hot springs area diorite inclusions are most numerous on the northern side of the Coso road. North and south of this area the dioritic masses become larger and in some localities become the main rock type; the granite there being present as small and irregular intrusions. Some of the diorite has undergone intense recrystallization and locally is practically a diorite-schist. The feldspar, biotite, and hornblende show good lineal arrangement and a uniform grain size. In other areas the rock has not been recrystallized. In such places the hornblende may show only minor chloritization but the feldspar is partly altered to sericite both along twinning planes and at the core of the crystal.

The typical basalt is composed of narrow laths of labradorite and rounded augite crystals in an exceedingly fine-grained groundmass of feldspar and magnetite. The labradorite laths make up approximately 20 percent, the augite anhedra 10 percent, and the groundmass 70 percent of the rock. Nearly one-third of the groundmass is small magnetite grains, the remainder being very fine-grained feldspar or glass. Some augite shows marginal alteration to biotite. The basalt wherever seen is characteristically fresh and has not been exposed to solfataric alteration.

The rhyolitic flows, obsidian, tuff, and volcanic breccia which occur throughout the Coso hot springs area apparently are derived from a nearly north-south line of craters located half a mile west of Devil's Kitchen. Some of these cones are more than 700 feet high, nearly circular, and composed of glassy lava fragments showing good flow structure. The large quantity of volcanic ash and breccia which blankets the surrounding country attests to the explosive character of the eruption.

A deeply excavated canyon at the Devil's Kitchen shows granite overlain by at least 100 feet of interbedded acidic lava flows and indurated ash beds. Well-indurated beds of volcanic breccia outcrop at intervals along the highway east of the Kitchen. The only exposed contact of breccia and underlying granite may be seen about 2,000 feet east of the Basin deposit and south of the main highway. The breccia lies on an uneven weathered granite surface which in places slopes as high as 35 degrees. Sand and granitic pebbles predominate in the lower beds and are overlain by tuff. The series of thin beds has a total thickness of approximately 12 feet.

Lava from the rhyolitic cones is largely composed of glass and a few small grains of quartz and fine biotite plates, together with small needle-like crystals aligned with the flow texture of the glass. Although these crystals cannot be positively identified many of them are probably quartz or feldspar. The light-brown, porous, rhyolitic flow breccia is composed wholly of volcanic glass and shows excellent flow structure. The vesicles are elongated and much of the glass appears as long fibers which bend around the vesicles.

South of Devil's Kitchen somewhat different characteristics are shown by the lava, which is fairly dense, fine-grained, and light gray in color. About 20 percent of the rock is quartz phenocrysts and 5 percent feldspar phenocrysts, both of which have an average diameter of 2 millimeters. Biotite and muscovite are minor accessories. Secondary quartz veins both the matrix and the primary phenocrysts. Spherulites are abundant.

The volcanic breccias and tuff are composed largely of fresh, unaltered volcanic glass. The coarser-grained tuffs contain many sand grains and presumably were water-laid. In addition, the tuff contains fragmental crystalline material of which quartz is most abundant, but orthoclase, sanidine, and andesine are also common. Microcline, hornblende, biotite, muscovite, and sericite are found in minor amounts. Limonite and hematite sometimes occur as coatings on other grains. The feldspar shows a wide range in alteration, some grains are fresh, others are mostly altered to sericite. The matrix of this tuffaceous material is composed almost entirely of glass.

The indurated tuffs are usually cemented with opal which, when present in large amounts, makes the tuff extremely hard and gives it a shiny siliceous appearance. Opal cement may comprise 20 percent of the rock. In a few places the cement is in part calcite and iron oxides presumably derived from the hot springs, or a yellow amorphous material apparently derived from alteration of the volcanic glass.

SOLFATARIC ALTERATION

The Coso hot springs area is unusually favorable for the study of solfataric action because rocks in the solfataric zones have been intensely altered, though away from the zones they are comparatively fresh. In areas of intense alteration the rocks have been reduced to a very porous pulverulent mass composed entirely of opaline silica. In many places it is difficult, if not impossible, to determine the nature of the original host rock. The most resistant rock material is dark volcanic glass present as fragments in the tuff. Its apparent resistance to alteration may in part be due to its extremely low porosity.

The alteration produced by the hot liquids and gases of the solfataric vents can be classified as silicification, kaolinization, and sericitization. The first indication of alteration as the solfataric zone is approached is shown by the addition of silica, usually in the form of opal but sometimes as chalcedony. This may be accompanied by sericite, usually restricted to feldspar or feldspar fragments. The opal or chalcedony appears as an irregular deposit in the matrix of the tuff, as a matrix replacement around fragments of volcanic glass, as small veinlets cutting tuff or granite, or as indefinite aggregated areas in granitic rocks. Kaolinization is particularly noticeable in rocks containing substantial amounts of volcanic ash. The kaolin forms as a coating on the glass and tuff fragments and sometimes apparently protects them from the complete opalization found in adjacent granitic material.

The granitic rocks show an interesting gradation in alteration in the vicinity of solfataric vents. The typical unaltered granite contains about 10 percent andesine, 15 percent albite, 30 percent antiperthite, 15 percent microcline, 25 percent quartz, 10 percent biotite, and minor amounts of magnetite and apatite. The andesine may be partially altered to sericite and kaolin but the other feldspathic constituents are fresh. Biotite may show some bleaching accompanied by the segregation of iron oxides parallel to cleavage directions. The first effect of solfataric alteration is shown by a bleaching of feldspar and biotite accompanied by deposition of opaline silica. Under more intense alteration the granite decreases markedly in specific gravity, the porosity increases, much of the feldspar is apparently removed, biotite is strongly bleached, and only quartz remains relatively unaltered. This stage of alteration is well shown by much of the granite exposed in the tunnels of the Basin Deposit and the road cuts at the southwest end of this deposit. Here the granite consists of a light buff, poorly consolidated mass which still preserves a granitic texture although the rock is largely composed of clay. Under the microscope this rock appears to consist of 25 percent quartz, 10 percent bleached biotite, 10 percent calcite, 5 percent magnetite, 2 percent andesine, 48 percent clay, and minor amounts of chalcedony.

Closer to the vents the granite is dirty white in color, and is composed of clay in which no dark constituents are visible, though a few quartz grains can be recognized. Under the microscope this rock is seen to contain about 30 percent quartz, the remainder of the material being clay through which magnetite is scattered as fine aggregates or individual grains.

In some areas the granite has undergone still more extreme alteration. In such places it is chalky in appearance, white to buff in color, and is composed almost entirely of fine-grained porous opal. Small particles of original quartz may still be recognized under the microscope but all of the other original minerals have been completely replaced by opal. This intensive opalization is often localized in the vicinity of small steeply dipping faults and the opalized material may grade within a few inches to kaolinitic alteration. However, even under the most intense alteration the granite preserves suffiicent of its coarse texture to distinguish it from altered volcanic material.

The rhyolitic lavas and tuffs, like the granite, are comparatively unaltered in areas removed from solfataric action. They have a characteristic buff color and show virtually no devitrification of the volcanic glass. Approaching the solfataric zone these rocks show increasing opalization and bleaching together with gradual devitrification accompanied by development of clay minerals. The tuffs and lavas, unlike the granite, never show complete opalization. Even under the most intensive alteration they preserve their banded appearance and fragments of unaltered volcanic glass, and areas of clay containing a core of volcanic glass.

SOLFATARIC AREAS

Three major loci of solfataric action are present within the described area. These are the Devil's Kitchen, the Basin Deposit, and Coso Hot Springs. The Devil's Kitchen is located on the line between Secs. 7 and 8, T. 22 S., R. 39 E., M. D. The Basin Deposit occurs about 2,000 feet northeast of the Kitchen, in the N½ Sec. 8. The Coso Hot Springs are about 2 miles to the northeast in the east central part of Sec. 4. Flowing hot springs occur in the Devil's Kitchen and in Coso Hot Springs.

At the Devil's Kitchen and the Basin Deposit, introduced minerals include opal, chalcedony, cinnabar, metacinnabar, sulphur, hematite, koalinite, and various iron sulphates. Cinnabar and metacinnabar occur both as painty disseminations throughout the opalized granite and tuff, and as narrow veinlets, subparallel to the bedding of the tuffs. At no place has mining development exposed any extensive concentration of mercury sulphides. In many places the cinnabar is accompanied by hematite. Sulphur is most abundant in the Devil's Kitchen where it forms as small but very well-developed crystals around the margin of small vents, on the sides of fragments, in breccia, and as black amorphous surface coatings on the altered rocks. Its deposition is obviously going on at the present time. In the upper levels at the south end of the Kitchen an attempt was made to mine sulphur. Alum and iron sulphate occur throughout the altered rocks. Alum commonly occurs as delicate white fibers that have a distinctly astringent taste. The iron sulphate is present mainly as an amorphous or very fine-grained green coating or crust on opalized wallrock.

No cinnabar or metacinnabar is present at Coso Hot Springs, but hematite, clay, opal, alum and iron sulphate are found in variable amounts.

STRUCTURE OF SOLFATARIC AREAS

While the Kitchen, Basin Deposit, and Coso Hot Springs zones occur along a fairly definite northeast line there is no evidence at the first two localities of any northeast-trending structures that might control the localization of these zones. At the Kitchen the greatest extent of the altered area is north and south but there is nothing to indicate that it is anything but an irregular alteration zone around a central vent.

The Basin Deposit has its greatest extent roughly parallel to the major east-west trend of the small valley in which it occurs. Although small faults and breaks are to be found at several places, they do not indicate any major structure indentifiable from the surface. The distribution of the mining pits appears to be haphazard.

The Coso hot springs, by contrast, are very clearly arranged along the east side of a small fault scarp which trends N. 30° E. and dips presumably to the east. This fault parallels the trend of Coso Valley at this point and probably is subsidiary to a major fault system. In the vicinity of the hot springs the fault shows a well-defined scarp that has an average elevation of about 10 feet. This fault can be traced for at least a mile and a half to the northeast. A short distance south of the main mud pit it appears to horsetail in the granite.

THE HOT SPRINGS

A number of active hot springs are located along the east side of the fault. These springs maintain a small pond at the surface and are piped to the Coso Hotel for heat and water. The surface appearance of the springs differs markedly from place to place—some are clear and transparent, others are loaded with white silt, and others are brick red from suspended iron oxides. The color change from white to red may be observed in vents only 3 or 4 feet apart.

The water level between springs 20 feet or less apart may differ by as much as 2 feet. This strongly suggests that the springs maintain individual channelways to a substantial depth. However, all of the springs show a marked seasonal variation in flow. This can be most readily observed in the large bath pit several hundred feet south of Coso Hotel. This pit is about 150 by 100 feet in area and 15 feet deep. The springs in the bottom of this pit continually discharge steam and hot sulphate waters. During the late summer the flow from these springs is only enough to maintain a very shallow, small pool in the bottom of the pit, whereas during the winter season the pool may be maintained at a maximum depth of 5 or 6 feet over the entire pit area. Evidently there is considerable intermixing of ground water and meteoric waters in these springs.

At the pit mentioned above, and also at other springs along the fault, the surrounding granitic rock has been altered to an extremely fine-grained white clay. This clay, which has long been used as a mud bath, is composed almost entirely of opaline silica and one of the kaolin-type minerals, probably nacrite or dickite, and contains in addition less than 0.25 percent of extremely fine-grained quartz grains. An analysis of this mud, collected by Mr. M. Dailey, is given in Table 1.

TABLE I

COSO BATH MUD

Constituent	*Composition (percent)*
SiO_2	50.50
Fe_2O_3	1.44
Al_2O_3	20.16
TiO_2	0.80
CaO	0.68
MgO	0.20
K_2O	1.45
Na_2O	0.45
H_2O minus 105° C	3.63
H_2O plus 105° C.	18.63
B_2O_3	None
P_2O_5	Trace
SO_3	1.39
Cl	0.13
CO_2	0.42
	99.88

Analyst, Smith-Emery Company, Los Angeles.

TABLE II

ANALYSES OF WATER FROM COSO HOT SPRINGS, INYO COUNTY, CALIFORNIA

(Constituents are in parts per million)

Properties of reaction:	*Sample 1*	*Sample 2*
Primary salinity	5	13
Secondary salinity	5	18
Tertiary salinity	90	69
Primary alkalinity	0	0
Secondary alkalinity	0	0
Tertiary alkalinity	(?)	45

Constituents	*By Weight*	*Reacting Values*	*By Weight*	*Reacting Values*
Sodium (Na)	49	2.13	81	3.52
Potassium (K)	11	.29	12	.31
Lithium (Li)	Trace	Trace	----	----
Ammonium (NH_4)	Trace	Trace	----	----
Calcium (Ca)	45	2.25	59	2.84
Magnesium (Mg)	2.4	.20	34	2.80
Iron (Fe)	122	4.98	83	2.97
Aluminum (Al)	201	22.22	56	6.20
Hydrogen (H)	16	15.98	12	11.67
Sulphate (SO_4)	2,308	48.05	1,400	29.18
Nitrate (NO_3)	Trace	Trace	0	.00
Chloride (Cl)	Trace	Trace	40	1.13
Carbonate (CO_3)	0	.00	0	.00
Metaborate (BO_2)	----	----	0	.00
Phosphate (PO_4)	Trace	Trace	Trace	Trace
Silica (SiO_2)	----	----	411	13.59
	2,754.4	----	2,188	----

1. Main Spring. Analyst, Oscar Loew (1876). Authority, Wheeler report.
2. Main Spring. Analyst and Authority, F. M. Eaton (1910).

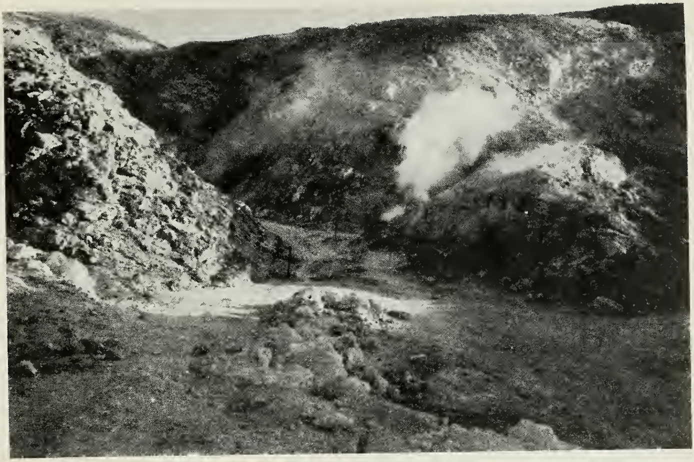

FIG. 1. Coso Hot Springs quicksilver deposit, Inyo County. *Photo. by Walter W. Bradley, October 1941.*

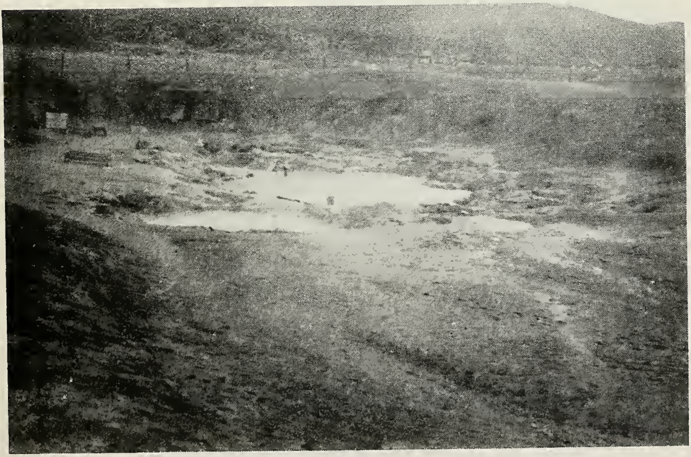

FIG. 2. Mud bathing pool, Coso Hot Springs, Inyo County. *Photo. by Walter W. Bradley, October 1941.*

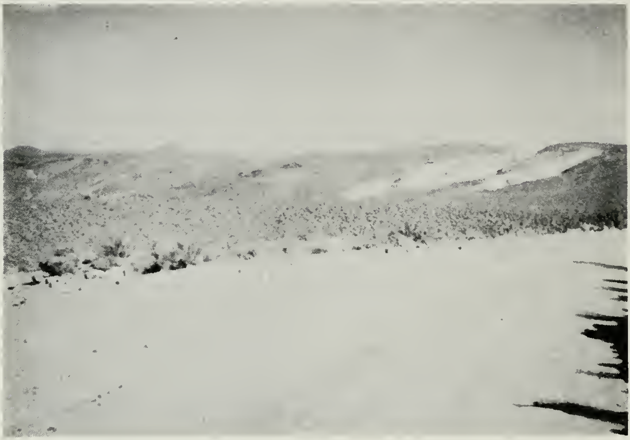

FIG. 3. Devil's Kitchen from the west side. The light-colored patches are zones of alteration. The Coso quicksilver mill can be seen on the left.

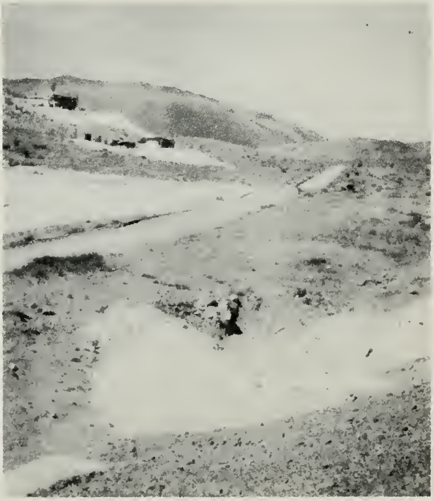

FIG. 4. A portion of the Basin deposit, and the Coso quicksilver mill. A large volcanic cone can be seen in the background.

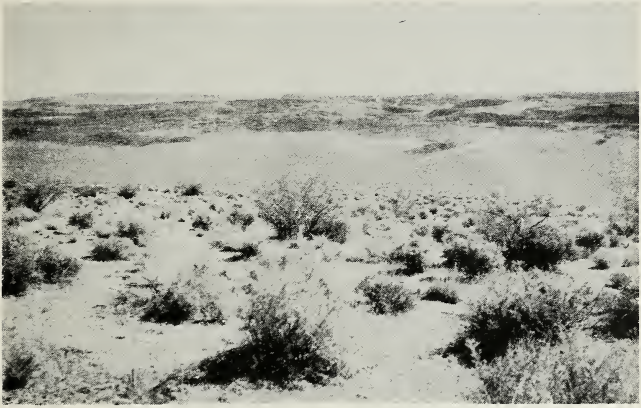

FIG. 5. View to the east from Coso Basin. The mountains in the background are cut by a series of step faults. Basic lava covers a large portion of these mountains.

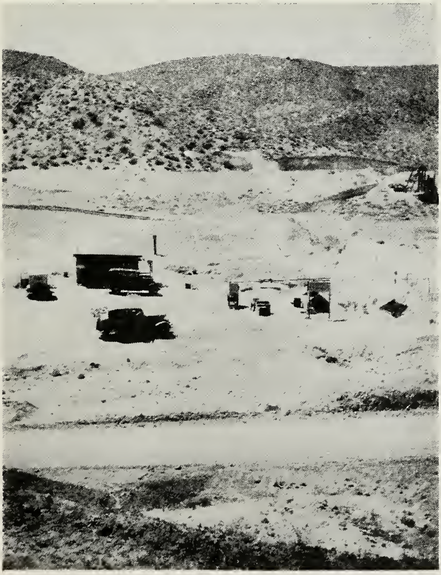

FIG. 6. Basin deposit, pits and trenches. The headframe of the 30-foot shaft can be seen to the right. The light-colored material is highly altered volcanic tuff.

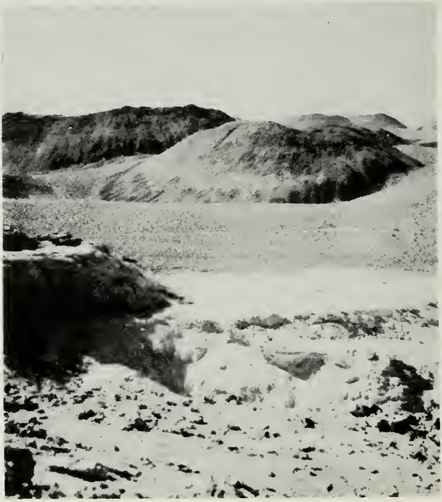

FIG. 7. View from the top of Devil's Kitchen to the northwest. In the foreground are pits in the altered tuff. Several volcanic cones can be seen in the background.

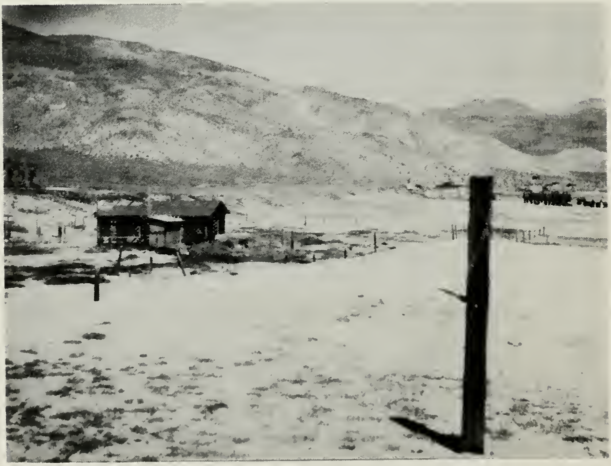

FIG. 8. Coso fault. The scarp can be seen in the alluvium. The fenced area is a zone of active springs.

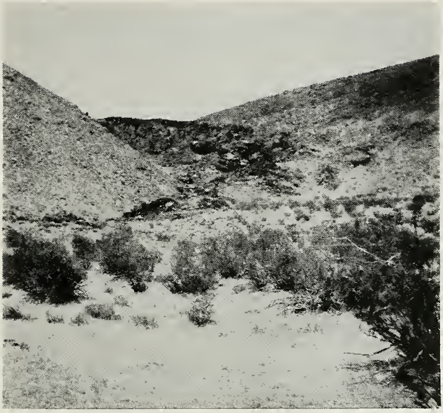

FIG. 9. A basic lava flow to the southeast of the map area, just west of the Coso Basin. The lava has flowed down a narrow canyon in the granite.

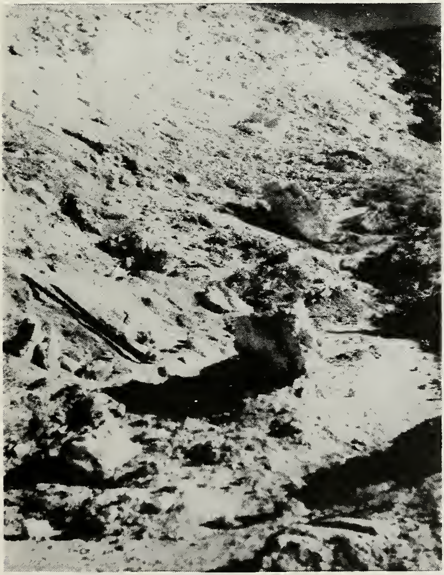

FIG. 10. A large cut on the west side of Devil's Kitchen. The bedding of the tuffaceous rocks can be seen in the upper part of the picture. This is a very active part of the Kitchen.

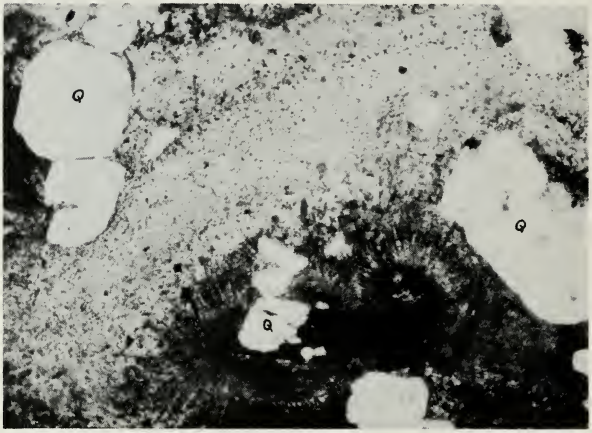

FIG. 11. Rhyolitic lava south of Devil's Kitchen showing phenocrysts of quartz and spherulites in the fine-grained groundmass of quartz and feldspar. Quartz (Q). x30.

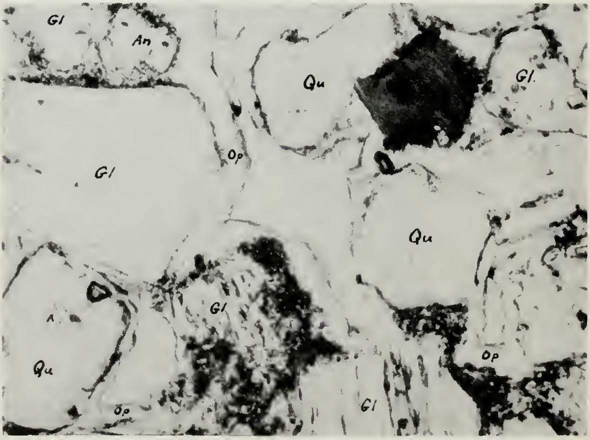

FIG. 12. Cemented volcanic breccia. Opal deposited in open spaces between fragments of glass, quartz, and biotite. Opal (Op), quartz (Qu), biotite (Bi), andesine (An). x110.

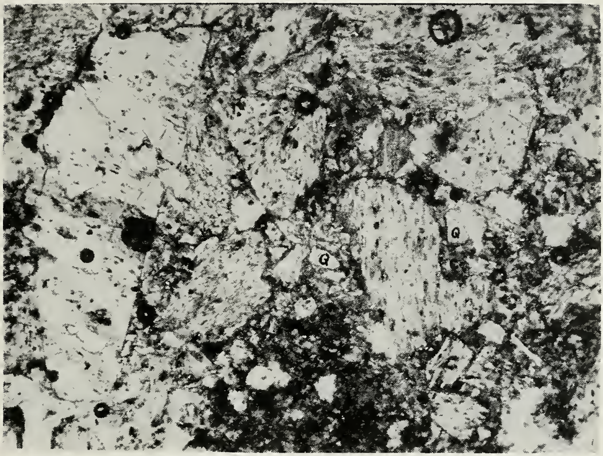

Fig. 13. Slightly altered volcanic breccia from Devil's Kitchen. Two small fragments of quartz (Qu). Large fragments are glass, matrix is largely glassy but contains a small amount of clay (C). x110.

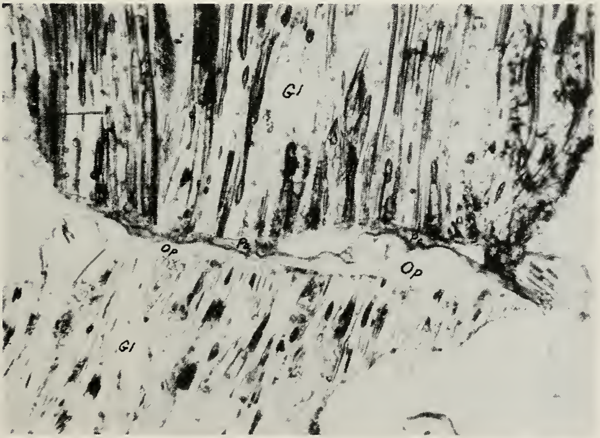

Fig. 14. Cemented volcanic tuff. Two glass fragments (Gl) cemented by opal (Op) and palagonite (Pa), the darker cementing material. x110.

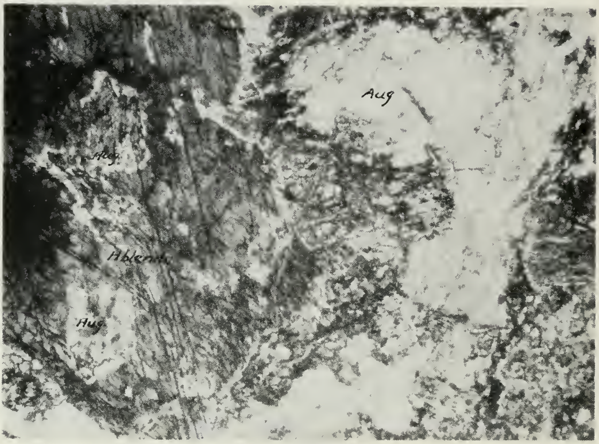

FIG. 15. A portion of the hornblende gabbro intrusive rock type. Augite (Aug) is partially altered to hornblende (Hblende) in this picture. Small inclusions of partially altered augite are present in the main hornblende crystal. x30.

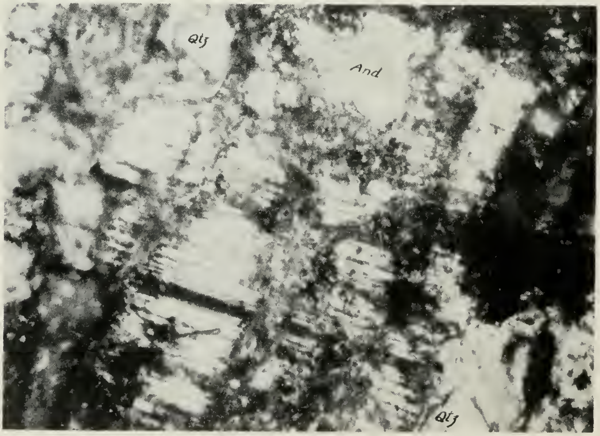

FIG. 16. A portion of an original granite which has undergone "moderate" alteration as a result of the action of hot gases and solutions. The andesine (And) is partially altered to clay (dickite or nacrite) and the quartz (Qtz) shows signs of corrosion. x110.

Although there are a number of fumarolic vents discharging gases in the Devil's Kitchen and Basin Deposit areas, active springs are limited to two, both in the Kitchen zone. One of these springs contains a substantial amount of suspended clay which gives it a milky color, the other is a clear white spring which appears to be depositing very little material.

CHEMICAL COMPOSITION OF THE SPRINGS

Three chemical analyses of water from the hot springs are available in the literature. Two analyses from the springs in the bath pit as quoted by Waring[8] are given in Table 2. Another analysis of water taken from the springs supplying the hotel is given in Table 3. These analyses all show the waters to contain a very high sulphate content together with substantial amounts of iron, aluminum, silica, calcium, and magnesium. There is a marked difference in the analyses made during a period of more than 50 years. It is not possible to determine the extent to which differences between the three analyses represent a change in the composition of the water rather than a change in the accuracy of the chemical determinations. However, some of the changes are so large as to suggest a substantial variation with time in the chemical composition of the spring waters.

TABLE III

COSO MINERAL WATER

Constituent	*Composition (parts per million)*
SiO_2	458.0
Al_2O_3	570.4
Fe_2O_3	13.6
P_2O_5	0.7
B_2O_3	0.0
$CaSO_4$	227.6
$MgSO_4$	5153.0
K_2SO_4	95.8
Na_2SO_4	1840.0
NaCl	3.8
Total solids	8362.9
H_2SO_4	452.2
$KMnO_4$	5.5

Analyst—E. F. Williams, Arthur R. Maas Laboratories, Los Angeles, California

SPECTROGRAPHIC ANALYSES OF HOT SPRINGS

In order to investigate variations in the minor constituents of water from the different springs, samples were collected from seven localities around Coso Hot Springs and from the main spring at Devil's Kitchen. These water samples were filtered and evaporated to dryness. A qualitative spectroscopic analysis of these eight samples is given in Table 4. Sample No. 1 was taken from Devil's Kitchen, samples No. 2 to 8, inclusive, were taken from the Coso Hot Springs area. The spectroscopic analyses were made in the laboratories of the Department of Geology, California Institute of Technology.

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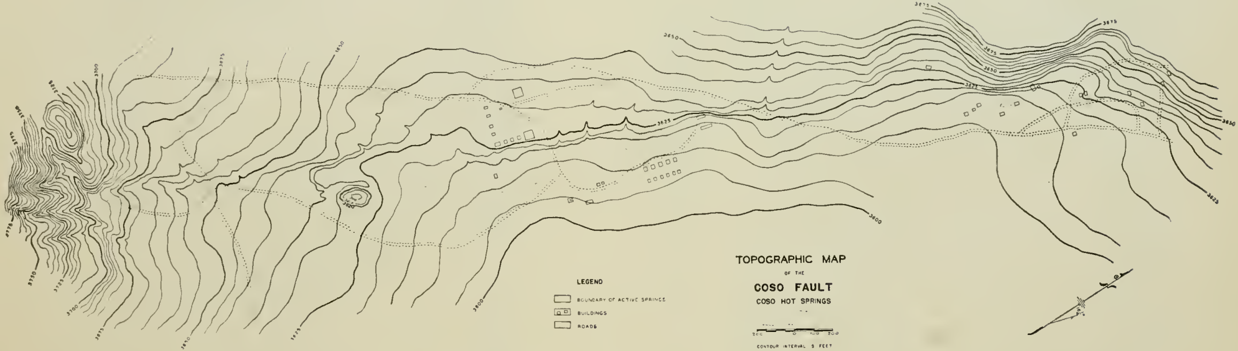
[8] Waring, G. A., Springs of California: U. S. Geol. Survey Water-Supply Paper 338, pp. 149-151, 1915.



TOPOGRAPHIC MAP
OF THE
COSO FAULT
COSO HOT SPRINGS

The analyses presented in Table 4 show a remarkable similarity both in the elements present and in the amounts for different samples. This is particularly surprising because these water samples came from red springs, white muddy springs, and clear springs, and also because the samples showed a considerable variation in the total amount of solids.

Another striking feature of these waters is the variety of elements present. To the 23 elements shown in Table 4 there must be added chlorine, sulphur, and carbon, whose presence has been proven chemically but which are not observable in an ordinary spectroscopic analysis. The presence of elements such as manganese, boron, zinc, lead, tin, vanadium, titanium, nickel, chromium, bismuth, and silver is strongly suggestive of a hypogene origin of these waters. One curious feature is the absence of mercury in solfataric water from the Devil's Kitchen, although cinnabar has been deposited throughout the rocks and its presence has been reported in the gases by several observers. Either the fluids are no longer transporting mercury or else it is present in the discharge only part of the time.

TABLE IV

SPECTROSCOPIC ANALYSES OF COSO HOT SPRING WATER

Sample No.	(Quantitative estimates, in per cent)							
	1	2	3	4	5	6	7	8
Element:								
Ca	10	10	10	10	10	10	10	10
Si	1–10	10	10	1–10	1	1–10	1	1–10
Al	10	1–10	1	1	1	1	1–10	1–10
Mg	1–10	1–10	1–10	1	1	1	1	1–10
Fe	1	.1	.1–1	1	.1	.1–1	.1–1	.1–1
Na	.1–1	1	1	.1–1	.1–1	.1–1	.1	.1–1
K	1	.1–1	.1–1	.1–1	.1–1	.1–1	.1–1	.1–1
Mn	.1	.1	.1	.1	.01–1	.01–1	.01	.1
Sr	.1	.1	.1	.1	.1	.1	.01–1	.1
Cu	.01–.1	.01–.1	.01–.1	.01	.01	.01–.1	.01–.1	.01–.1
Zn	.01–.1	.01	.01	.01	.01	.01	.01	.01
Ba	.01	.01	.01–1	.1	.01–1	.01	.001–.01	.01
B	.01–1	.01–.1	.01	.01	.01	.001–.01	.01	.001–.01
Pb	.01	.01	.01	.01	.001–.01	.001–.01	.001–.01	.01
Sn	.01	.01	.001–.01	.001–.01	.001	.001	.01–.001	.01–.001
V	.01	.001	.001	.01–.001	.01–.001	.001	.001	.001
Ti	.01	.001–.01	.001–.01	.001–.01	.001–.01	.001–.01	.001–.01	.001–.01
Ni	.01	.001	.001	.001	.001	.001	.001–.01	.001
Cr	.001–.01	.001	.001–.01	.001	.001–.01	.001–.01	.001–.01	.001–.01
Bi	.001	.001	.001	.001	.001	.001	.001	.001
Ga	.001	---	---	---	---	---	---	---
Be	tr	tr	tr	tr	---	---	tr	tr
Ag	.0001–.001	.0001	.0001–.001	.0001	.0001	.0001	.0001	.0001
Per cent by weight of dissolved salts	0.70	0.23	0.41	0.37	0.36	0.43	0.69	1.00

Sample:	Description and location
1.	Clear water from main spring in Devil's Kitchen, about 50 feet south of concrete mud bath basin.
2.	Clear water from small stream east of shelter at Coso Hot Springs, main springs area.
3.	Iron-stained spring, clear water, from spring with concrete pier, south of sample 2.
4.	Clear water from spring in stone-cribbed well, 65 feet south and west of shelter.
5.	Red water from spring in stone-cribbed well due west of shelter.
6.	Deep red water from spring at edge of pond, 45 feet north of sample 5.
7.	Milky white water from spring at north end of mud bath pit.
8.	Clear water, spring at south end of mud bath pit.

CINNABAR DEPOSITS

The presence of cinnabar in the Coso Hot Springs district was recognized prior to 1925 but no effort was made to exploit the deposits until that year. Since then there have been intermittent attempts at production by several companies. It is estimated that the total quicksilver output from the several deposits in the Coso Hot Springs district totals approximately 200 flasks.

Mercury has been produced mainly from the Devil's Kitchen and Coso Basin deposits although some exploration had been carried on in Coso valley about 2 miles southeast from Coso Hotel. The deposits have been developed by open cuts, pits, trenches and several short adits.

Virtually all the mercury is present in the form of cinnabar, which occurs as small seams, disseminated grains, and "painted" coatings throughout the porous, highly altered tuffs and granite. At the Devil's Kitchen the principal minerals accompanying the cinnabar are metacinnabar, sulphur, hematite, alum, and iron sulphate salts. In the Basin Deposit metacinnabar and hematite accompany the cinnabar. Much of the cinnabar rapidly turns black when exposed to sunlight,[9] and metacinnabar is thus less abundant in the deposits than would be apparent from the casual examination of surface material.

Because there are no confining structures, no concentration of cinnabar occurs in the deposits. Cinnabar disseminations are extremely irregular in shape and distribution. Mineralized seams rarely exceed 2 or 3 inches in width. They likewise are irregular both in strike and dip and cannot be traced for more than a few feet in any direction. A number of narrow gouge seams, possibly the result of slumping in the wall rocks as alteration proceeded, apparently have acted as minor controls on cinnabar distribution.

Eighteen samples were analyzed, of which about one-half were picked from supposedly high-grade seams and pockets in the altered tuff and granite. The highest assay was obtained from a small stringer which showed 1.1 percent mercury. Carefully selected areas may show a mercury content, across a foot or so, of as much as 0.5 percent or 10 pounds to the ton. However, the average content of altered rock is very slow, being less than half a pound per ton, and even selective mining will probably not yield an average production of much better than a pound to the ton. The district affords an excellent example of the deposition of cinnabar under very near-surface conditions, where governing structural control is lacking.

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[9] Dreyer, R. M., Darkening of cinnabar in sunlight: Am. Mineralogist, vol. 24, no. 7, pp. 457-461, 1939.

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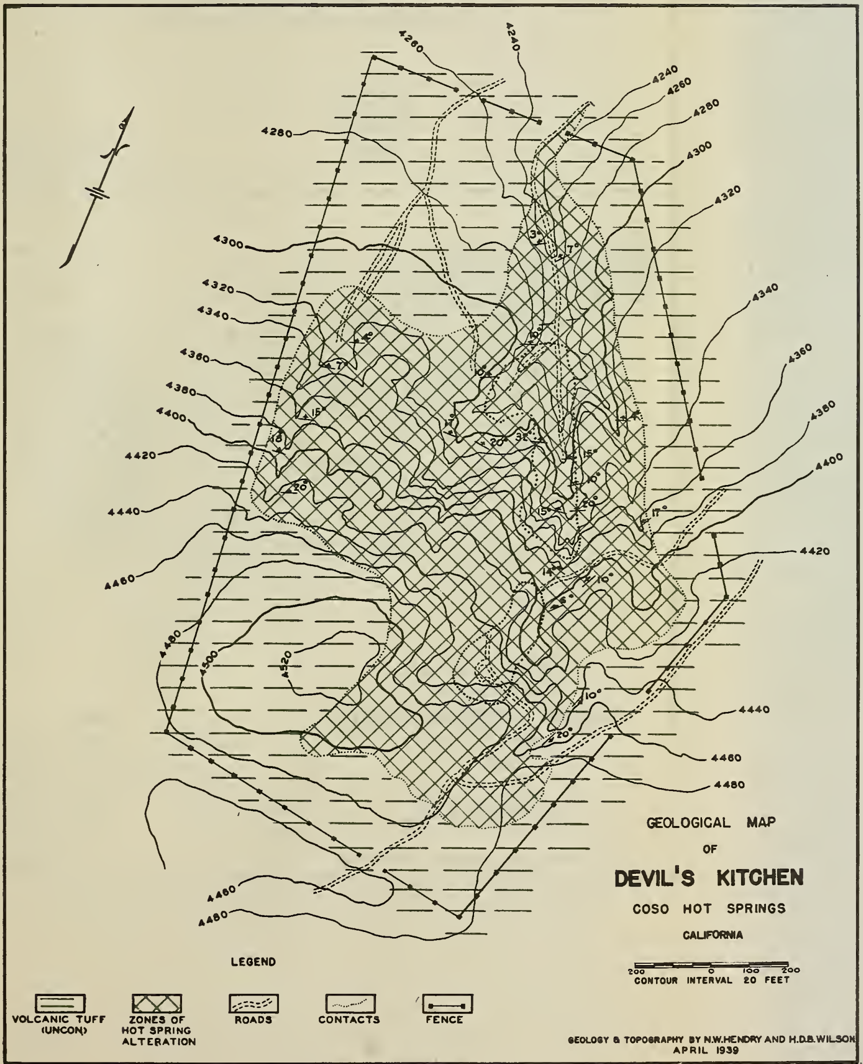
PLATE V



GEOLOGICAL MAP
OF
DEVIL'S KITCHEN
COSO HOT SPRINGS
CALIFORNIA

CONTOUR INTERVAL 20 FEET

GEOLOGY & TOPOGRAPHY BY N.W. HENDRY AND H.D.B. WILSON
APRIL 1939

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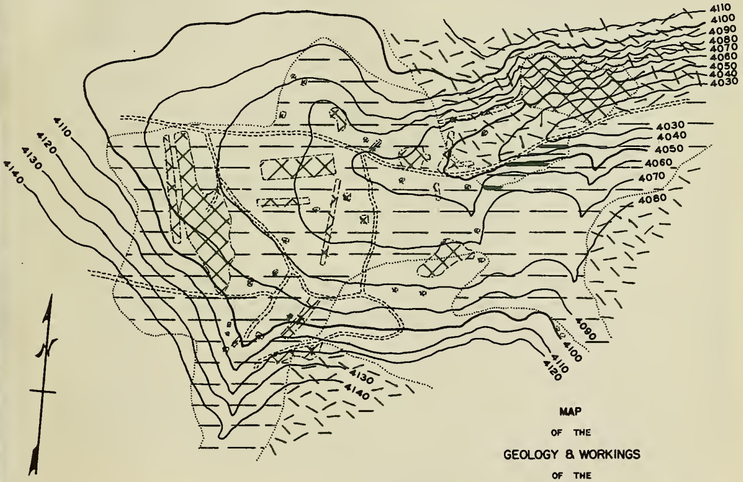
PLATE VI



MAP
OF THE
GEOLOGY & WORKINGS
OF THE

COSO MERCURY DEPOSIT

COSO HOT SPRINGS
CALIFORNIA

200 0 100 200
CONTOUR INTERVAL 10 FEET

LEGEND

- ☐ ALLUVIUM (GR.)
- ☰ VOLCANIC TUFF (UNCON.)
- ▨ ALTERED ZONES
- ▤ BEDDED VOLCANICS
- ⧄ GRANITE
- ⅄ ADIT
- ▣ SHAFT
- ⬚ CONTACTS
- ⬚ PITS & TRENCHES

GEOLOGY AND TOPOGRAPHY BY N.W.HENDRY & H.D.B.WILSON
APRIL 1939

ACCOMPANYING STATE MINERALOGIST'S REPORT XXXVIII, JULY—OCTOBER, 1942

CONTACT METAMORPHIC ROCKS OF THE TWIN LAKES REGION, FRESNO COUNTY, CALIFORNIA*

By Charles W. Chesterman

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ABSTRACT

The contact-metamorphic rocks of the Twin Lakes region are located along the north side of Kaiser Crest some 3 miles north of the easternmost end of Huntington Lake, Fresno County, California. They occur as irregular pod-shaped roof pendants whose long axes trend slightly north of west. They are made up essentially of metamorphosed sedimentary rocks. They were formed as limestones, argillaceous sandstones, and basic lava flows which were altered by profound metamorphic action of intruding granitic rocks (quartz monzonite). The limestones were changed to marbles; the impure limestones to calc-silicate hornfels; the argillaceous sandstones to schists, gneisses, and quartzites; and the basic lava flows to actinolite-hedenbergite-epidote rocks and skarns. Scheelite (an ore-mineral of tungsten) occurs in the skarns.

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* This report is the result of work done in partial fulfillment of the requirements for the degree of Master of Arts at the University of California, Department of Geological Sciences. Manuscript submitted for publication October, 1942.

INTRODUCTION

The writer spent 8 weeks during the summer of 1939 studying and mapping the geology of the immediate region about Twin Lakes, near Kaiser Peak, Sierra National Forest, Fresno County, California. A topographic map was made of the area which included an isolated body of crystalline limestone. Laboratory studies supplemented the field work; more than 70 thin-sections were prepared and examined under the microscope. In the summer of 1942 the writer revisited the area with Olaf P. Jenkins and discovered several deposits of scheelite (one of the chief ore-minerals of tungsten) in the skarns.

Acknowledgments

The writer wishes to thank members of the faculty of the Department of Geological Sciences of the University of California, especially Professors Howel Williams and Adolf Pabst, for guidance in the study of this problem. Professor W. M. Tucker of Fresno State College very kindly supplied survey equipment, and Professor A. R. Addington of the same institution assisted the writer in the field in the preparation of the detailed map which accompanies this report. Re-study of the area in 1942, with particular attention to a search for scheelite was suggested by Olaf P. Jenkins, Chief Geologist of the California State Division of Mines, and made possible by the Gold Hill Dredging Company of San Francisco.

Geography

The Twin Lakes region is located in the central part of the Kaiser quadrangle (fig. 1) about 3 miles north of the eastern end of Huntington Lake, Fresno County. It lies in T. 7 S., R. 26 E., M. D., and comprises about 14 square miles centered around Twin Lakes and extending from Kaiser Pass westward along Kaiser Crest to a point slightly east of Kaiser Peak.

The high elevations, jagged cliffs, and steep crags of the Twin Lakes region are typical of the Sierra Nevada. Glacial and stream action are largely responsible for the present relief features. Twin Lakes occupy cirque basins situated on the north slope of Kaiser Crest at an average elevation of 8,500 feet. The topography in the immediate vicinity of Twin Lakes is not as rugged as that of Kaiser Crest. A small medial moraine separates Twin Lakes.

Geology

The rocks of the Twin Lakes region belong to the Bedrock series of the Sierra Nevada. They are pre-Cretaceous in age, and consist of two groups: (1) pre-granitic stratified rocks, including some igneous intrusives and flows, all greatly altered by the intrusion of the Sierra Nevada granite batholith; and (2) granitic rocks, which, at the close of the Nevadan orogeny, intruded as a batholith the older folded sedimentary series.

The pre-granitic rocks are thoroughly metamorphosed. The original stratified form of the sediments is indicated only by banding of the hornfels and crystalline limestone. The original sediments were probably marine limestones, argillaceous sandstones, cherts, and clay shales.

As shown on the accompanying geologic map, there are three detached roof pendents, of which the one at Twin Lakes is the largest; their general strike is N. 60-70° W., parallel in a general way to the trend of Kaiser Crest.

At the highest elevations along Kaiser Crest metamorphic rocks of siliceous character occur; the quartzites and schists are apparently more resistant to erosion than the surrounding igneous rocks.

From an elevation of 8,500 feet at Twin Lakes, Kaiser Crest rises to 10,000 feet; the highest point is Kaiser Peak, elevation 10,300 feet. The southern slope of Kaiser Crest, which drains into Huntington Lake and Big Creek, is not as steep as the northern slope which drains into Kaiser Creek. Water from both enters the San Joaquin River.

The western of Twin Lakes has subterranean drainage. During early summer when its level is above normal, water flows over a natural dam on the north shore, and passes underground through an opening in the marble, to emerge 25 feet lower in elevation and 1000 feet farther north. The eastern lake has surface drainage, which is largely controlled by the water-level. During early summer, when the lake is full of water, its outlet is through a small meadow into Kaiser Creek. When there is insufficient water to pass over the natural dam near the north end of the lake, subsurface drainage lowers the water-level appreciably.

The region about Twin Lakes is accessible during summer months. Paved highways connect San Joaquin Valley and Huntington Lake. A dirt road runs from Huntington Lake to Kaiser Pass and thence to Kaiser Peak Meadows. A good trail connects Huntington Lake and Kaiser Peak Meadows, passing through the Twin Lake area.

The general strike of the crystalline limestone and intercalated calc-silicate hornfels is N. 50° W., the dip is very steep. The structure may represent the remaining limb of a highly folded anticline or syncline. A small fault lies along the line of subterranean drainage from the west lake; its strike is N. 20° E.

DESCRIPTION OF THE PLUTONIC IGNEOUS ROCKS

General Features

There are four types of igneous rocks present in the Twin Lakes region: (1) biotite-hornblende-quartz monzonite; (2) biotite-hornblende-quartz diorite; (3) gabbro; and (4) pegmatites. Of the four listed, the monzonite and diorite are most abundant.

Whether or not there was a single intrusion is not known. The structure is complex. The monzonite and diorite grade into each other, showing no definite contacts. They were regarded as a unit and no attempt was made to map them individually.

Biotite-Hornblende-Quartz Monzonite

The biotite-hornblende-quartz monzonite is not as widely distributed in the Twin Lakes region as the diorite. The former occurs in two distinct varieties, porphyritic and non-porphyritic. In the porphyritic variety microcline feldspar occurs as phenocrysts ranging from ½ to 2 inches in length. Their outline is sharply defined, and on the weathered surface of the rock they are so distinct that their crystallographic character can easily be discerned from a distance of at least 5 feet. These phenocrysts are enclosed in a moderately coarse-granular aggregate of quartz and whitish alkali and soda-lime feldspars, interspersed with small amounts of biotite and hornblende.

The non-porphyritic variety has essentially the same mineral composition as the porphyritic variety, but lacks phenocrysts. Since the two varieties differ only by the presence or absence of phenocrysts, they will be described as one rock type.

The texture of the monzonite is essentially hypautomorphic-granular and porphyritic. The phenocrysts are diverse in their occurrence, being abundant in some places and almost lacking in others. In general there are at least ten of the phenocrysts to a square foot of the rock.

The basic plagioclase feldspar, constituting about 34 percent of the rock, occurs in the groundmass as grains rarely showing crystal faces. Both albite and carlsbad twinning are present, but the albite predominates. Decomposition of the plagioclase, yielding kaolin and sericite, is more pronounced in the smaller crystals than in the larger ones.

Myrmekite is most common where potash feldspar contacts plagioclase feldspar.

Potash feldspar occurs in the groundmass and as phenocrysts. It occurs occasionally as a perthitic orthoclase, but generally as microcline; both forms may occur together. As phenocrysts they show distinct crystal outline with slightly rounded corners. The phenocrysts are not composed entirely of potash feldspar, but enclose numerous unoriented crystals of plagioclase, all of which have corroded borders or borders of myrmekite. The potash feldspar of the groundmass occurs as euhedral and subhedral crystals averaging about 4 mm in diameter, constituting approximately 33 percent of the rock.

The quartz occurs in the form of small granules or anhedral crystals and encloses numerous needle-like crystals of either rutile or tourmaline; it constitutes approximately 17 percent of the rock.

Both biotite and hornblende are moderately abundant in the monzonite. The biotite is typically brown in color, the hornblende is green. Both minerals occur as subhedral crystals and exhibit the usual degree of pleochroism. The biotite has been slightly altered to chlorite, but the hornblende is fresh.

The minor accessory minerals of the monzonite are zircon in euhedral grains; sphene as inclusions in the biotite and hornblende; apatite as inclusions in the feldspars; and magnetite, which occurs sparingly in the biotite and hornblende as small euhedral inclusions.

Biotite-Hornblende-Quartz Diorite

The biotite-hornblende-quartz diorite is the most widespread and abundant granitic rock in the Twin Lakes region. It is gray in color and has a medium to fine grain-size. Plagioclase and potash feldspars constitute the leucocratic minerals; biotite and hornblende are the melanocratic minerals. The secondary minerals are sphene, apatite, and magnetite.

The texture of the diorite is hypautomorphic granular. Occasionally porphyritic texture occurs, but not as frequently as in the monzonite.

Plagioclase feldspar, which constitutes about 45 percent of the rock, occurs in the form of intermediate andesine. Zoning and twinning are common. The zoned crystals are, as a rule, much larger than those not zoned, and they also tend to exhibit a higher degree of euhedralism. The type of zoning present is oscillatory, in which the interior or core of the crystal is much more basic than the exterior. Boundaries between zones are sharp. Cutting across zoned crystals are twin lamellae of combined albite and carlsbad type.

Myrmekite is common around the smaller plagioclase crystals. The plagioclase feldspar contains inclusions of biotite, hornblende, and magnetite. On the whole, the rock appears to be quite fresh, and shows only a small amount of sericite and kaolin; this secondary alteration is most prevalent in the smaller plagioclase crystals and in the cores of the zoned crystals.

The potash feldspar, microcline, constitutes approximately 12 percent of the rock; it occurs as anhedral crystals.

Minor amounts of quartz are present, occurring as anhedral crystal grains. There are no needle-like inclusions in the quartz. Strain-shadows appear under the microscope; they are probably due to stresses set up during the period of cooling.

Hornblende, the ordinary green variety, occurs as subhedral and anhedral crystals, some of which have been slightly altered to chlorite. Occurring in approximately the same amount is a brown biotite, which has been altered in places to a deep grass-green chlorite; under crossed-nicols this exhibits alternate bands of ultra-blue and brown abnormal interference colors.

The minor accessory minerals occur in small amounts—1 or 2 percent. Apatite, magnetite, and zircon are all present, usually as small inclusions in the feldspars and ferromagnesian minerals.

	1.	2.	3.	4.
SiO_2	72.16	71.67	70.52	71.66
Al_2O_3	15.56	15.44	11.90	13.52
Fe_2O_3	0.08	0.00	0.80	1.03
CaO	1.48	2.05	3.89	4.69
MgO	1.34	0.44	0.81	1.14
FeO	1.45	0.44	2.50	2.01
Na_2O	1.11	2.81	4.03	2.91
K_2O	5.95	7.06	2.83	2.89
H_2O	0.29	0.09	0.08	0.14
	99.42%	100.00%	97.35%	99.99%

1. Biotite-hornblende-quartz monzonite. From Kaiser Crest about one mile west of Kaiser Pass.
2. Biotite-hornblende-quartz monzonite. From Kaiser Crest about half a mile north of Potter Pass.
3. Biotite-hornblende-quartz diorite. From a ridge about one mile north of the eastern end of Huntington Lake.
4. Biotite-hornblende-quartz diorite. From about 50 feet north of the northern contact between crystalline limestone and igneous rock.

The preceding analyses were computed by using the Wentworth integrating stage. An average of 12 traverses were made on each of the thin-sections and the analyses were calculated using the pure mineral molecules.[1]

Gabbro

Approximately 100 feet south of the small lake located just to the northeast of Potter Pass is a small outcrop of gabbro which measures about 20 feet in diameter. This is the only outcrop of gabbro found in the Twin Lakes region, and its relations to the diorite are none too certain since the contacts are indistinct owing to the glacial overburden.

The gabbro is normal in composition. It is dark greenish-gray and medium to fine grained. The two constituents are augite and intermediate labradorite. The texture is hypautomorphic-granular.

The augite, occurring in anhedral and subhedral crystals, constitutes approximately 55 percent of the rock. It is pale-green and very slightly pleochroic. Under the microscope the mineral appears as fresh crystals.

The feldspar crystals are medium in size and constitute approximately 44 percent of the rock. The feldspar is intermediate labradorite in composition and exhibits numerous twinning lamellae of the albite type. This mineral, as in the case of the augite, is also fresh in appearance and it is only along cleavages and fractures that small amounts of alteration have taken place.

Sphene and apatite are the accessory minerals in the gabbro. They constitute about 1 percent of the rock. The sphene occurs as automorphic and xenomorphic crystals and is usually found as inclusions in the later-formed minerals. The apatite occurs in small automorphic crystals as inclusions in the augite and plagioclase feldspar.

Pegmatites

Pegmatite dikes ranging from 3 to 5 inches in width intrude the igneous and some of the metamorphic rocks of the Twin Lakes region. No pegmatites were found cutting the main body of crystalline limestone at Twin Lakes. The dikes, in general, strike N. 30-40° W. and dip toward the southeast and northwest at high angles.

The pegmatites are made of quartz, microcline, biotite, and almandine garnet. The garnet, in most cases, exhibits no crystalline forms and appears as masses enclosed in the pegmatites. The pegmatites in the metamorphics just east of Potter Pass sometimes cut across, and sometimes follow the planes of schistosity. A lit-par-lit type of gneiss was formed, but has only a limited occurrence.

The southwestern portion of the main body of crystalline limestone at Twin Lakes is a small skarn deposit. Cutting it at various attitudes are a number of small pegmatite dikes ranging from half an inch to 18 inches in width. These pegmatite dikes are somewhat different than those previously described in that they contain magnetite and epidote as well as quartz, microcline, and almandine garnet. The garnet has a specific gravity ranging from 3.93 to 4.10 and a mean index of refraction of 1.810 ± .001. In thin-section it is strongly birefringent and exhibits lamellae which resemble those of plagioclase feldspar.

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[1] Johannsen, Albert, A Descriptive Petrography of the Igneous Rocks, vol. 1, p. 292, 1939.

CONTACT METAMORPHISM

Contact-metamorphism of the pre-granitic rocks of the Twin Lakes region has given rise to a variety of metamorphic types: hornfels, quartzite, gneiss, schist, crystalline limestone, skarn, and actinolite-hedenbergite rocks.

The degree of contact-metamorphism is fairly uniform across the strike and dip of the beds as exemplified by the main body of crystalline limestone. The width of the zone of metamorphism as exposed on the surface depends upon the attitude of the igneous contact; the hornfelses are exposed over a wide area when the bottom of the metamorphic rock is not very far below the present surface.

Metamorphism of the limestone has been of the following types: (1) recrystallization of the limestone and dedolomitization of the dolomitic limestone, also reduction of the carbonaceous material to graphite; and (2) formation of contact-metamorphic minerals under relatively high pressure and temperature without abundant mineralizers. The minerals were formed in the following manner: (a) by recrystallization of the impure limestone to form spinel, wollastonite, diopside, tremolite, pargasite, magnetite, grossularite, idocrase, clinozoisite, epidote, and anorthite; (b) by hydrous emanations at a later stage from the magma containing halides and borates to form phlogopite and clinohumite. A small amount of tungstic acid accompanied the hydrous emanations from the magma and gave rise to the contact-metamorphic mineral, scheelite. The formation of brucite by hydration of periclase took place probably during cooling of the intrusion.

The destruction of pre-existing structures in the original sediments and the development of coarsely crystalline rocks indicate that a complete chemical reaction was involved and that the material was cooled slowly, under uniform pressure.

The temperature at which the metamorphic processes took place is questionable. Anorthite is a mineral indicative of high temperature, but what the presence of wollastonite may indicate is uncertain. Relatively high temperatures are needed to form wollastonite, but whether the temperature at which anorthite is formed is higher than that is not known by the writer. In the feldspathic quartzite, which is surrounded by crystalline limestone, the potash feldspar does not contain threads of albite (perthite). This fact may indicate that when the orthoclase crystallized, the temperature was low, and no albite could be taken into solid solution to separate out later to form perthite.

CONTACT METAMORPHIC ROCKS

Hedenbergite-Orthoclase-Quartz Gneiss

The easternmost roof-pendant is composed essentially of hedenbergite-orthoclase-quartz gneiss and biotite quartzite. These rocks form the small peak just east of Potter Pass; they are resistant to erosion and stand out in contrast to the surrounding igneous rocks. Both rock types are so closely related that no contact separating them was drawn on the map. The gneiss is limited to this one particular roof pendant, but the biotite quartzite can be found in all of the roof pendants.

The gneiss is pale apple-green in color and fine-grained. It is composed essentially of bands of hedenbergite which alternate with bands of orthoclase and quartz; in places it is contorted and intricately folded. The texture is granoblastic and the rock is completely recrystallized (fig. 7).

Most of the rock is composed of hedenbergite which is a pale yellow on a weathered surface, and a darker color on a fresh surface. The chemical composition, as determined by optical properties, was found to be 90 mol percent hedenbergite and 10 percent diopside.

Orthoclase occurs in granoblastic bands, containing considerable amounts of quartz and sphene. The grain-size and width of bands vary considerably, but the average diameter of the grains is approximately 0.10 mm. The orthoclase lacks twinning. It constitutes about 35 percent of the rock (figs. 20, 21).

Quartz, occurring in granoblastic aggregates and bands with the orthoclase, constitutes about 30 percent of the rock. The xenoblastic crystals vary in size and often show strain shadows.

Scattered through the rock are several irregular relict crystals of deep grass-green hornblende which, in a few instances, are intergrown with the hedenbergite. The presence of mutual intergrowths indicates that the hedenbergite was derived in part from hornblende, and that during metamorphism not all of the hornblende was used; the excess recrystallized as hornblende.

Sphene occurs as an accessory mineral, and can be found in irregular crystals scattered throughout the rock.

To ascertain how, and from what the gneiss originated, is very difficult. The dominance of potash over soda and the high silica content favor its sedimentary origin. However, the dominance of CaO over MgO and the presence of recrystallized hornblende tend to indicate an igneous origin.[2]

Biotite-Muscovite-Chlorite-Quartz Schist

The biotite-muscovite-chlorite-quartz schist is more widely distributed than any of the crystalline siliceous metamorphic rocks. It occurs abundantly in the easternmost roof-pendant, is present in the main body of crystalline limestone at Twin Lakes, and occurs with biotite quartzite at Kaiser Peak.

The rock shows evidence of recrystallization to a hornfels; its schistose character is not very well developed. The plane of schistosity parallels the general strike of the original bedding. The texture is crystalloblastic; idioblasts of biotite and muscovite are enclosed in a granoblastic aggregate of quartz, sphene, magnetite, and chlorite.

Biotite occurs as small, olive-brown idioblastic crystals which rarely measure more than 1 mm in diameter; small pleochroic halos surround zircon crystals in the biotite. These pleochroic halos are found in the biotite; a few occur in the chlorite (fig. 22).

The muscovite is colorless and occurs in small xenoblastic crystals scattered throughout the rock. It is far subordinate to the biotite and can be seen under the microscope only when the nicols are crossed.

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[2] Bastin, E. S., Jour. Geology, vol. 17, p. 445, 1909.

Pale-green chlorite can be found as irregular flakes in the rock. The chlorite flakes are much larger than any of the other minerals present. Cutting the chlorite are small idioblastic crystals of biotite which have been developed from the chlorite.

The quartz, occurring in small xenoblastic crystals in granoblastic aggregates, constitutes about 50 percent of the rock. Included in the quartz are numerous small, black inclusions which are probably graphite.

The minor accessory minerals include zircon, sphene, and magnetite; they occur as small grains and in small amounts, constituting not more than 1 percent of the rock.

In all probability the schist was derived from an argillaceous sandstone which contained quartz, chlorite, kaolin, and magnetite. Upon metamorphism, the biotite was formed from a portion of the chlorite, kaolin, and quartz. The remaining kaolin recrystallized as muscovite, the remaining chlorite as biotite. These changes took place in the mesozone which is characterized by considerable temperature and uniform pressure, and strong directed pressure. All of the above properties are characteristic of dynamothermal metamorphism. However, the writer believes that this rock owes its present form and characteristics to recrystallization brought about by contact metamorphism following dynamothermal metamorphism.

Biotite Quartzite

The biotite quartzite is one of the lightest-colored siliceous metamorphic rocks of the Twin Lakes region. It outcrops abundantly in the easternmost roof-pendant and at Kaiser Peak, but is relatively scarce in the body of crystalline limestone at Twin Lakes.

The texture of the biotite quartzite is essentially granoblastic with a mosaic structure. Quartz is the essential mineral and constitutes about 90 percent of the rock; its crystals are equigranular and average 0.8 mm in diameter. It has recrystallized into a clear quartz-mozaic with no traces of the original clastic character. Inclusions of zircon and sphene are common minor accessory minerals in the quartz (fig 23).

The biotite is dark olive-brown in color and occurs in small xenoblastic crystals. Such secondary minerals as sericite, chlorite, and limonite will give rise to biotite upon contact or dynamothermal metamorphism. Small amounts of dark-green irregular crystals of hornblende are present. Besides small amounts of hornblende, there are a few small, colorless crystals of zoisite which exhibit distinct abnormal blue interference colors. The origin of the zoisite is unknown. However, chlorite, calcite, kaolin, and quartz will alter to zoisite through contact metamorphism.

Near the top of Kaiser Peak a small exposure of this biotite quartzite was found which contained a small amount of black tourmaline. The tourmaline occurs essentially as little rosettes covering the surfaces of fractures and cracks in the quartzite. It is apparent from the mode of occurrence that the tourmaline is pneumatolytic in origin and was deposited in the fractures by ascending emanations from the crystallizing igneous intrusion.

The biotite quartzite was probably an impure sandstone whose impurities were chlorite, sericite, calcite, kaolin, and limonite, plus minor amounts of zircon and sphene. The zircon and sphene were not affected by the alteration, but the other secondary minerals reacted together and formed biotite, hornblende, and zoisite.

Feldspathic Quartzite

The feldspathic-quartzite outcrops in only one locality, which is located near the south-central part of the body of crystalline limestone at Twin Lakes. Here the quartzite exposure is 8 feet wide. It was mapped along its strike for a distance of 100 feet, and then lost under a cover of soil and glacial debris. On both sides is coarse crystalline limestone; the contact is distinct and sharp.

The texture of the feldspathic quartzite is granoblastic; occasionally there is a porphyroblast of quartz and potash feldspar enclosed in a granoblastic aggregate of quartz, potash feldspar, plagioclase feldspar, and minor amounts of sphene, green biotite, and epidote. Secondary graphic intergrowths of quartz and potash feldspar occur, but they are few in number, and are scattered through the rock with no apparent relationship to one another; they cause the rock to resemble a quartz porphyry (fig. 24).

The quartz in this rock occurs in two forms. With the potash feldspar it forms a granoblastic aggregate enclosing the large porphyroblastic crystals of quartz and feldspar. The porphyroblasts in some cases are relatively large, measuring 1 mm or more in diameter; they are rounded, and show strain shadows under the microscope. The quartz in the granoblastic groundmass occurs as xenoblastic crystals measuring 0.2 to 0.3 mm in diameter, and forms a mosaic structure with the feldspars. The combined two forms of quartz constitute approximately 60 percent of the rock.

Orthoclase, which constitutes about 20 percent of the rock, occurs in xenoblastic crystals in a granoblastic groundmass with the quartz and plagioclase feldspar. Albite, the plagioclase feldspar, makes up about 10 percent of the rock.

The minor accessory minerals are sphene, green biotite, zircon, epidote, magnetite, and limonite. The sphene, zircon, and magnetite occur as small rounded and irregular grains in the groundmass. The biotite is pale-green in color and occurs in irregular crystals. The epidote is colorless in thin-section but under the crossed-nicols it exhibits ultra-blue abnormal interference colors. Local accumulations of magnetite are common; associated with the magnetite is secondary limonite, probably derived in part from the magnetite. There is a tendency for all of the accessory minerals to group themselves together as clots or concentrations.

The original sediment was probably a feldspathic sandstone containing minor impurities in the form of calcite, chlorite, limonite, and sericite. These secondary minerals reacted together to form the epidote, biotite, and plagioclase feldspar.

The absence of perthite indicates that the temperature at which this rock formed was relatively low in comparison with that for the formation of the wollastonite.

Crystalline Limestone

In general, the main body of crystalline limestone occurs in the roof-pendant at Twin Lakes proper. However, there is a small outcrop of brucite marble at the northwest tip of the easternmost roof-pendant.

At this particular place the brucite marble is bordered on all sides by biotite schist and gneiss. The large body at Twin Lakes is surrounded by diorite and everywhere the contact was observed it was distinct.

The crystalline limestone is composed of three distinct types: calcite marble, dolomitic marble, and brucite marble. Of the three types listed the first is most widespread. No attempt was made to separate each type in the field.

The original bedding of the limestone can easily be traced in the field. The strike is essentially the same all over the exposure but there seems to be considerable difference in the directions of the dip (fig. 3).

Calcite Marble

The calcite marble is the most widespread of the three types to be described. It varies from practically colorless to statuary-white and, in places, sky-blue. The color usually occurs in bands; gray in some of the bands is due to finely-disseminated crystals of graphite. The color bands range in width from a few inches to a few feet, some bands 10 feet wide were found.

The calcite marble from Twin Lakes, according to chemical analyses, is generally composed of fairly pure calcium carbonate. Below is a partial analysis of a medium-grained gray calcite marble from the eastern part of the crystalline limestone body at Twin Lakes:

	Percent
CaO	47.42
MgO	5.92
Insol.	1.20

The specific gravity of this marble is 2.69, slightly less than 2.71, the specific gravity of pure calcite. The insoluble material was determined in thin-section and was found to consist of graphite, diopside, quartz, and idocrase. Both quartz and idocrase occur in well-formed crystals showing numerous faces. The diopside, on the other hand, occurs in rounded and irregular grains. There is no apparent orientation of the impurities in the marble; even the graphite, which occurs in small disseminated crystals, has no definite orientation.

A colorless to white variety of calcite marble occurs interbedded with the gray variety, in approximately equal proportions. The colorless is more coarsely crystalline than any other marble of the region, regardless of chemical composition.

Strain features are common in the calcite marble; it is most highly developed in the darker gray varieties which occur in narrow bands than in the clear and white varieties. The sheared and strained marbles may represent the relict texture and structures which were imposed on the limestone during the period of regional and dynamothermal metamorphism, and the clear and slightly sheared marble represents that which was recrystallized by contact-metamorphism (fig. 25).

In thin-section the sheared marble shows very little fracturing. Measurements of the sheared crystals were made with the mechanical stage, and it was observed that the crystals of calcite are five times as long as they are wide, or, taking the width as the unit one, the ratio of elongation is 5:1. In the field the long axis is parallel to the strike, and the short axis is normal to the bedding.

Dolomitic Marble

A dense, fine- to medium-grained dolomitic marble occurs in the crystalline limestone at Twin Lakes. This marble, in particular, is usually white. The following partial chemical analysis shows the relative proportions for CaO and MgO in the marble.

	Percent
CaO	33.54
MgO	27.83
Insol.	1.43

The insoluble residue consists of diopside and some unidentifiable material. The diopside is in rounded grains. The specific gravity of the dolomitic marble is 2.91, slightly higher than that for pure dolomite.

Included in the dolomitic marble is a pure white, medium-grained marble of practically pure dolomite, $CaMg(CO_3)_2$. An exposure of this pure dolomite was found about half a mile northeast of the eastern lake, where it forms a small cliff. Strained and sheared zones occur in the dolomitic marble.

Scattered throughout the dolomitic and calcite marbles are numerous disconnected clusters or accumulations of minerals which were formed by contact-metamorphic action. These unusual accumulations include such minerals as tremolite, diopside, phlogopite, spinel, grossularite garnet, clinohumite, and anorthite. The tremolite occurs in idioblastic crystals, 1 to 2 inches in length; it is extremely white, exhibiting shining crystals in contrast with the dull marble matrix. These crystals have no common orientation, but occur in crisscrossing mats, or as nodular lumps protruding from the marble.

The diopside found in the marble occurs in three distinct colors—pink, white, and dull gray. Of the three, the pink exhibits the best developed crystals. The dull gray diopside occurs in parallel and radiating clusters in which the crystals are somewhat platy. The white diopside, on the other hand, is exceedingly widespread in its distribution. One particular occurrence is located about 1000 feet north of the eastern lake and is closely associated with tremolite and wollastonite. Here the diopside is abundant and forms a rather prominent outcrop. This white diopside is very pure, for the mean index of refraction was found to be 1.672 — 0.002, a figure very close to the pure molecule diopside. A spectrographic analysis by Dr. T. G. Kennard shows the following:

Large amount	Calcium Magnesium Silicon
Small amount (x.xx%)	
Very small amount (0.XX%)	Aluminum Iron
Traces only (0.0X — 0.000X%)	Lithium Sodium Barium Strontium Copper Manganese Boron Lead Titanium

ILLUSTRATIONS ACCOMPANYING REPORT

By Charles W. Chesterman

CONTACT-METAMORPHIC ROCKS OF THE TWIN LAKES REGION, FRESNO COUNTY, CALIFORNIA

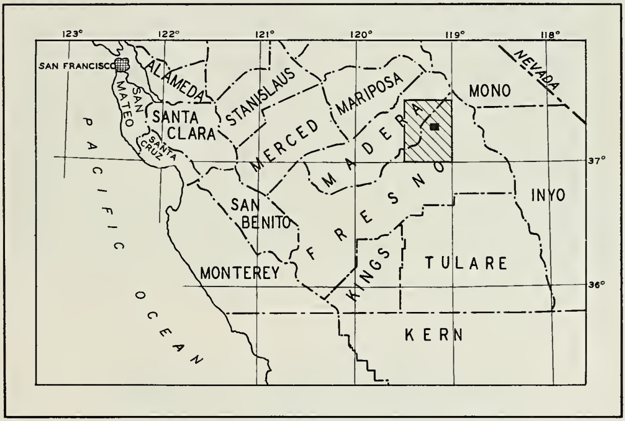

Fig. 1. Index map, showing location of Twin Lakes area (solid black) in the Kaiser quadrangle (line-ruled).

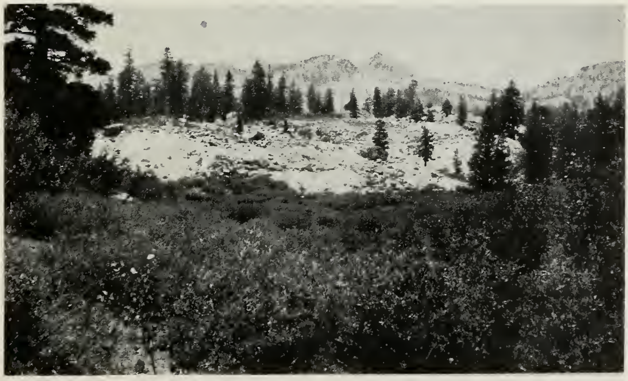

Fig. 2. General view of the crystalline limestone body just north of the eastern lake of Twin Lakes. Kaiser Crest in background. Large glacial erratic rests on limestone.

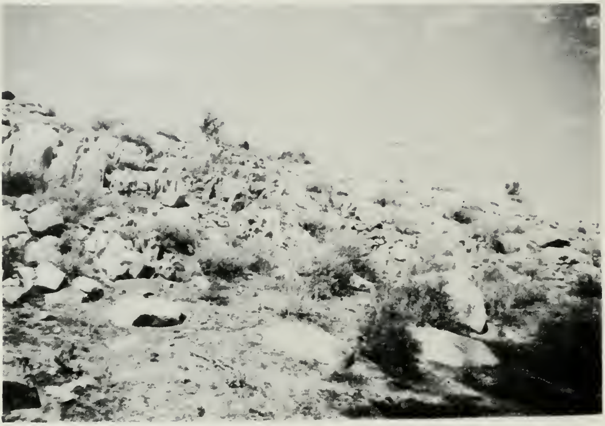

FIG. 3. Crystalline limestone showing bedding; weathered on surface. Beds in center of picture are dark gray; those on each side are light gray to almost white. Glacial erratics in foreground.

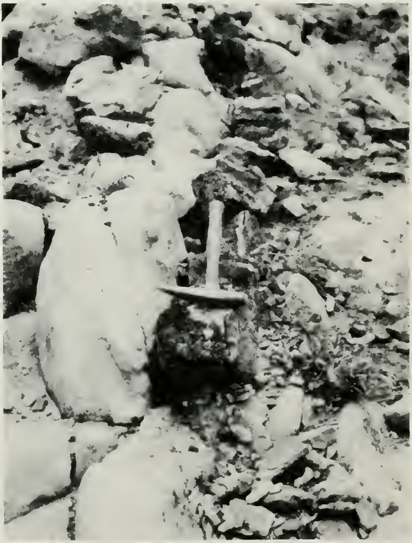

FIG. 4. Spinel-bearing calc-silicate hornfels zone. Note distinct contact between crystalline limestone and hornfels; width of zone is approximately 10 inches.

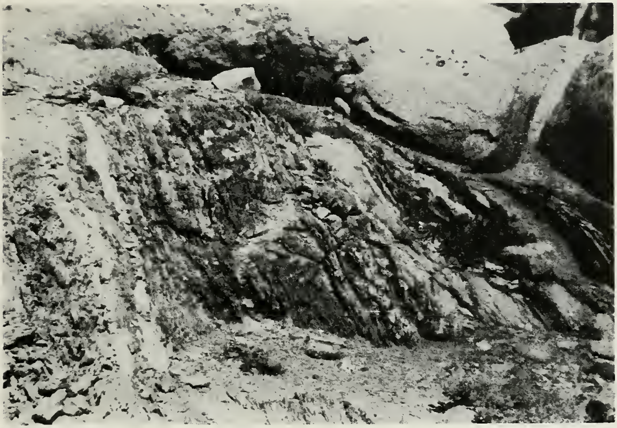

Fig. 5. Wollastonite-grossularite-plagioclase hornfels. The white bands on the left are wollastonite and calcite. Glacial erratics lie on hornfels.

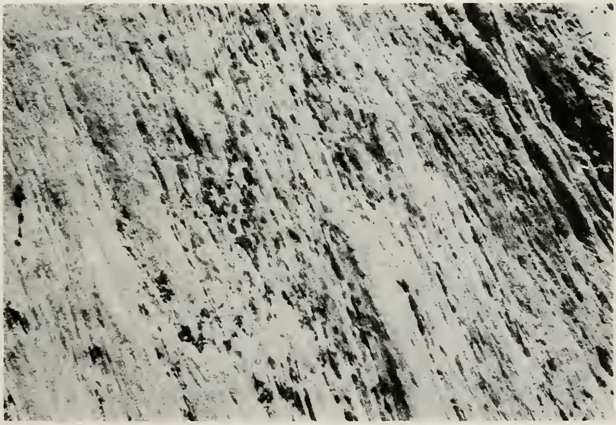

Fig. 6. Close-up view of the wollastonite-grossularite-plagioclase hornfels and marble showing deformation of the rocks.

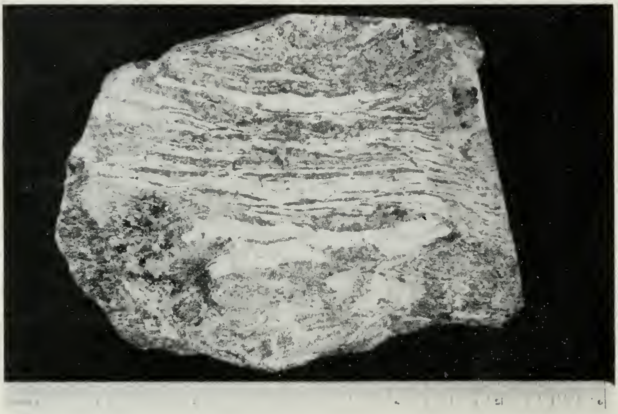

FIG. 7. Hedenbergite-orthoclase-quartz gneiss, showing banded structure.

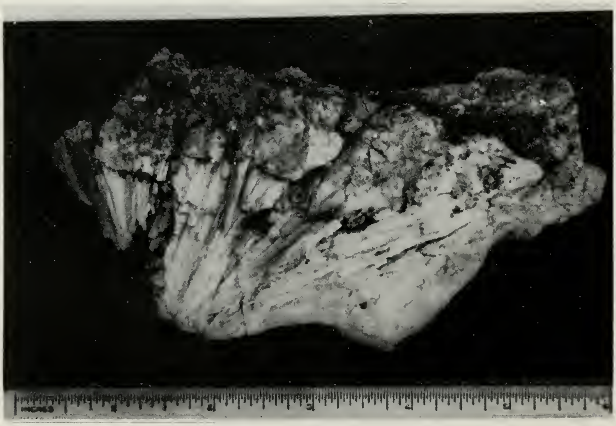

FIG. 8. Radiating tremolite in marble.

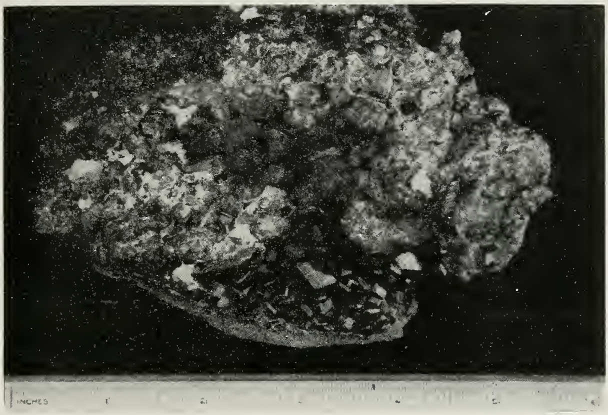

FIG. 9. Aggregate of grossularite garnets in a cavity, showing development of crystal forms.

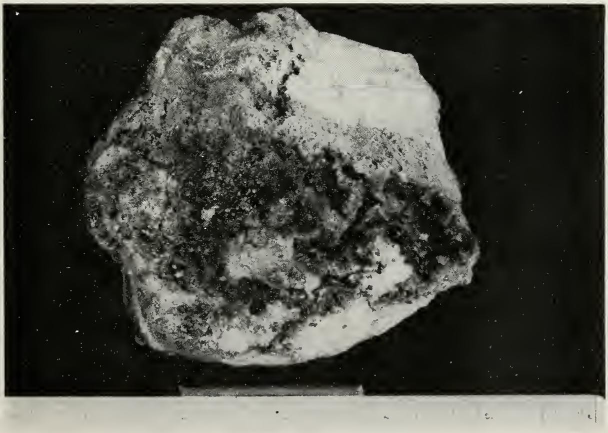

FIG. 10. Spinel crystals in calc-silicate hornfels.

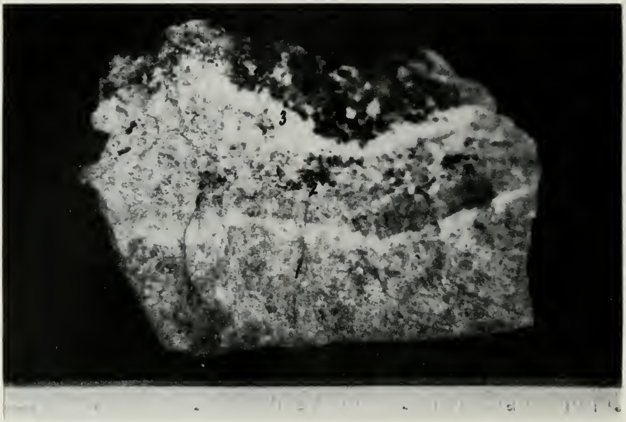

FIG. 11. Zoned spinel-bearing calc-silicate hornfels. (1) massive orange-red grossularite; (2) mixture of green spinel, calcite, garnet, and pyrrhotite; (3) calcite, phlogopite, and idocrase, (4) phlogopite and idocrase.

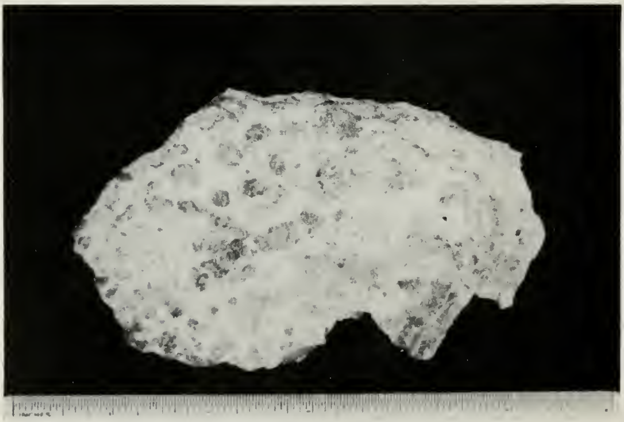

FIG. 12. Calc-silicate hornfels showing development of grossularite garnet in granular matrix of diopside, calcite, clinozoisite, idocrase, and plagioclase feldspar.

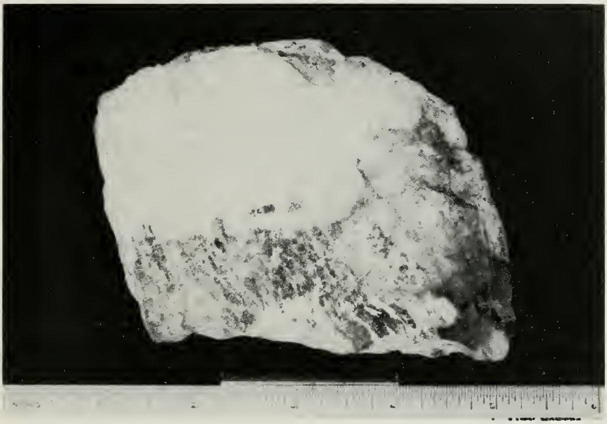

FIG. 13. Development of tremolite in calc-silicate hornfels.

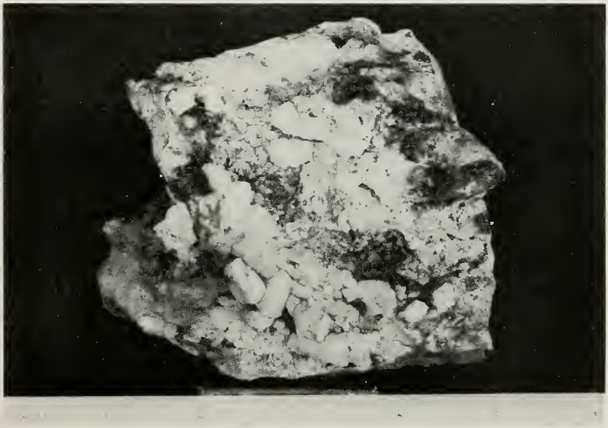

FIG. 14. Cluster of orthoclase feldspar crystals in calc-silicate hornfels with epidote and garnet.

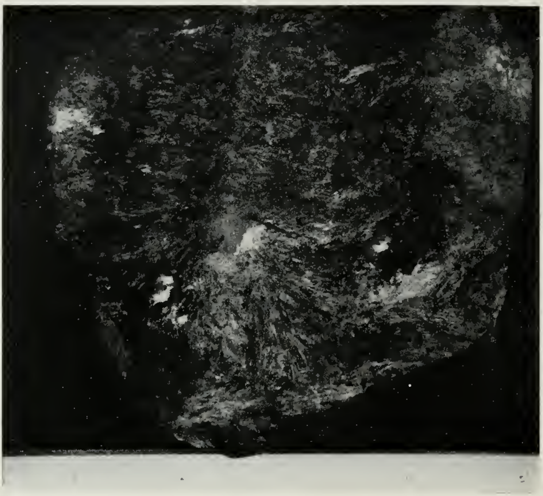

FIG. 15. Actinolite from actinolite-hedenbergite-epidote showing radiating and banded structure.

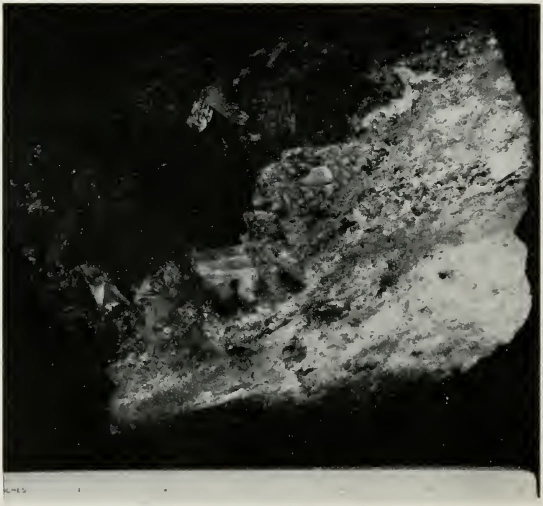

FIG. 16. Mirolitic cavity in pegmatite showing development of epidote.

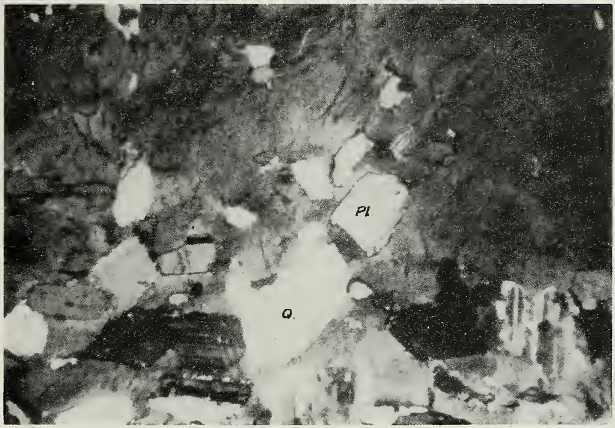

FIG. 17. Inclusions of plagioclase feldspar and quartz in a large orthoclase feldspar phenocryst of the biotite-hornblende-quartz monzonite. Crossed nicols. X 23. Q—quartz, Pl.—Plagioclase feldspar.

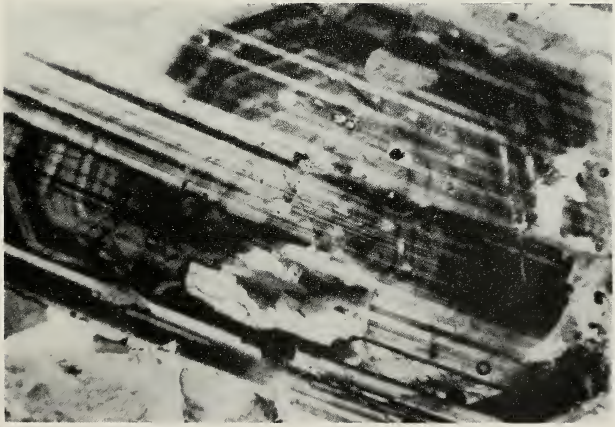

FIG. 18. Photomicrograph. Zoned and twinned andesine crystal in the biotite-hornblende-quartz diorite. Crossed nicols. X 25.

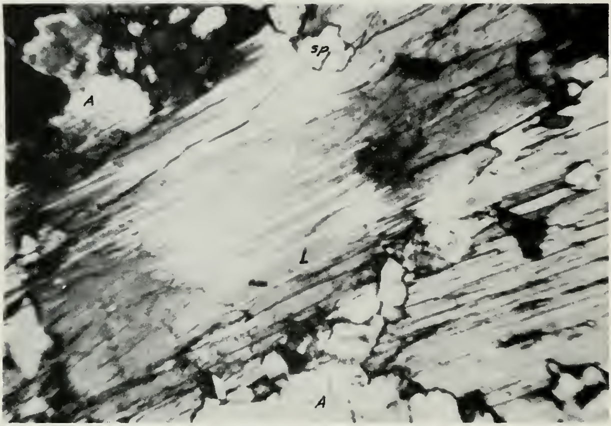

FIG. 19. Photomicrograph. Twinned labradorite in the gabbro. Crossed nicols. X 25. A—augite, L—labradorite, Sp—sphene.

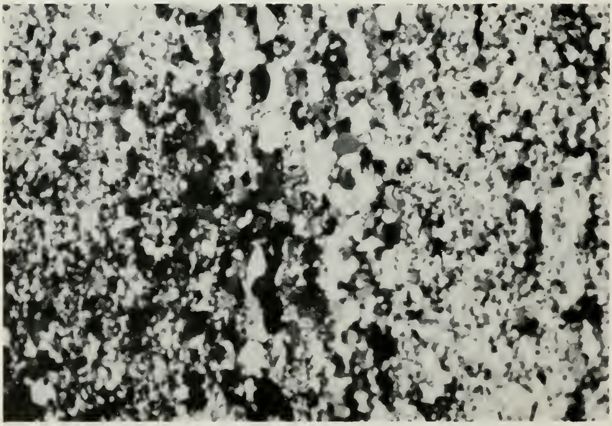

FIG. 20. Photomicrograph. Hedenbergite-orthoclase gneiss. Ordinary light. X 22.

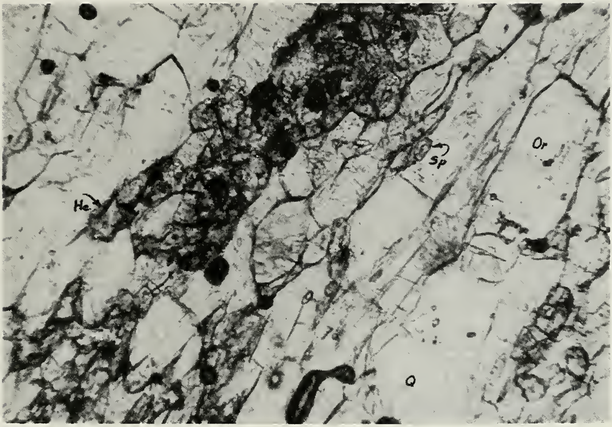

Fig. 21. Photomicrograph. Hedenbergite-orthoclase-quartz gneiss. Ordinary light. X 50. H—hedenbergite, Or—orthoclase, Q—quartz, Sp—sphene.

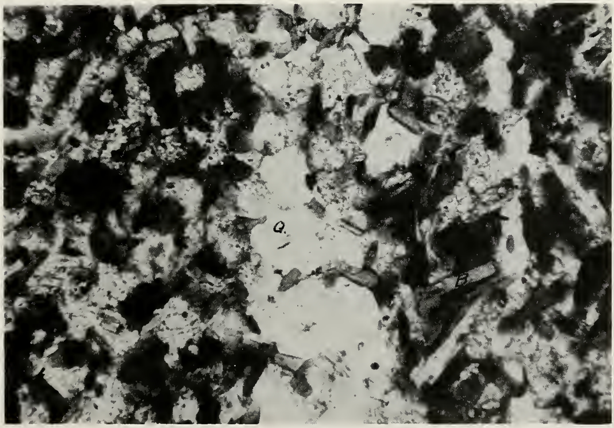

Fig. 22. Photomicrograph. Biotite-muscovite-chlorite-quartz schist, showing oblique orientation of biotite crystals. Crossed nicols. X 50. Q—Quartz, B—biotite.

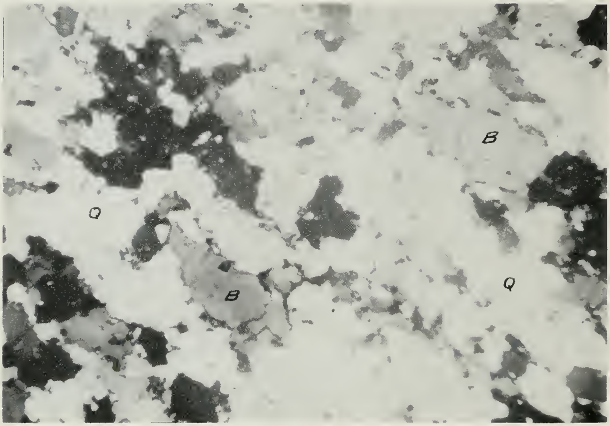

FIG. 23. Photomicrograph. Biotite quartzite, showing suture structure. Crossed nicols. X 22. B—biotite, Q—quartz.

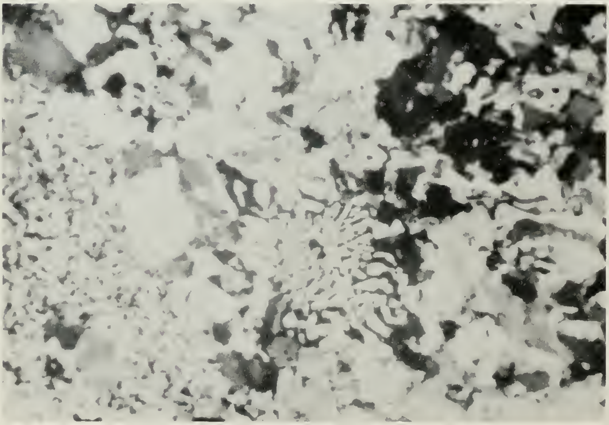

FIG. 24. Photomicrograph. Feldspathic quartzite showing differential grain size and graphic intergrowth of quartz and orthoclase feldspar. Crossed nicols. X 25.

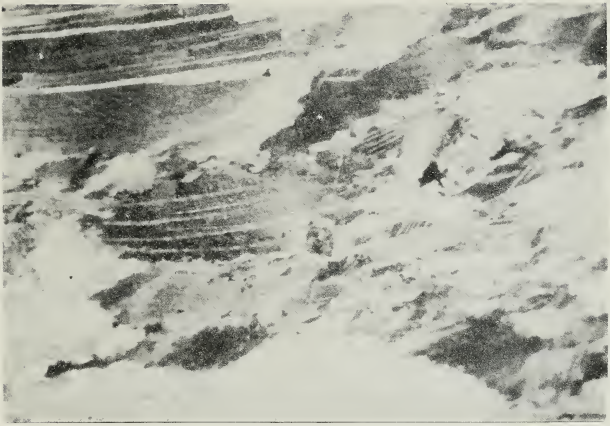

FIG. 25. Photomicrograph. Sheared calcite marble, showing bending of the twinning lamella of the calcite. Crossed nicols. X 23.

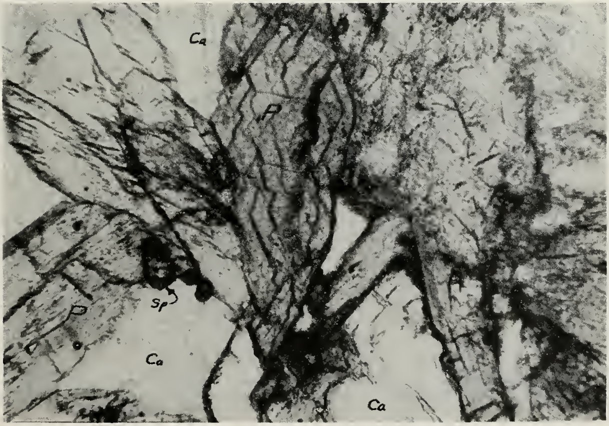

FIG. 26. Photomicrograph. Pargasite with calcite and sphene in spinel-bearing calc-silicate hornfels. Ordinary light. X 50. P—pargasite, Sp—sphene, Ca—calcite.

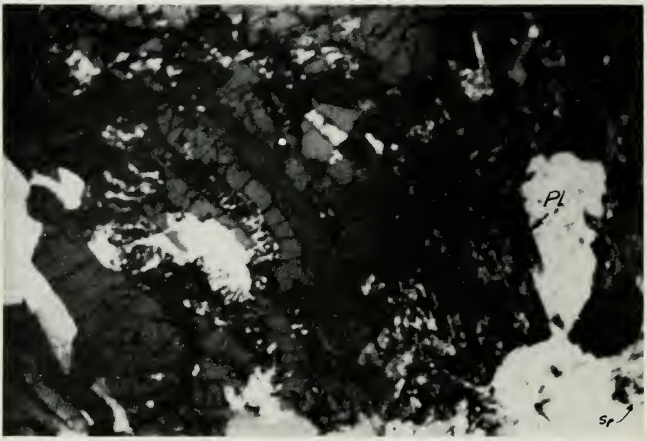

FIG. 27. Idocrase with plagioclase feldspar, calcite, and sphene in spinel-bearing calc-silicate hornfels. Crossed nicols. X 25. Id—idocrase, Sp—sphene, Pl—plagioclase feldspar.

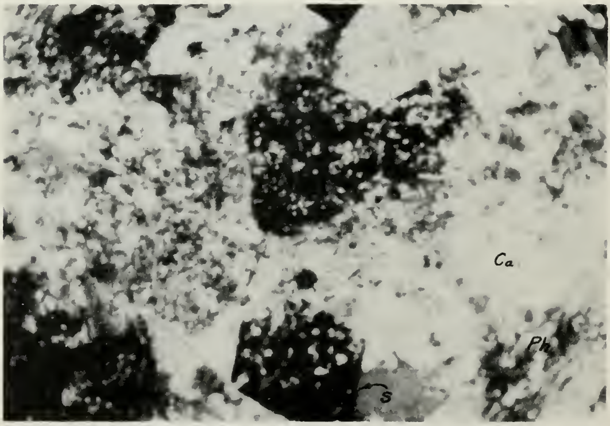

FIG. 28. Photomicrograph. Poikiloblastic spinel (black rhombs) with calcite, diopside, sphene, and phlogopite in spinel-bearing calc-silicate hornfels. Crossed nicols. X 25. S—spinel, Ph—phlogopite, Ca—calcite.

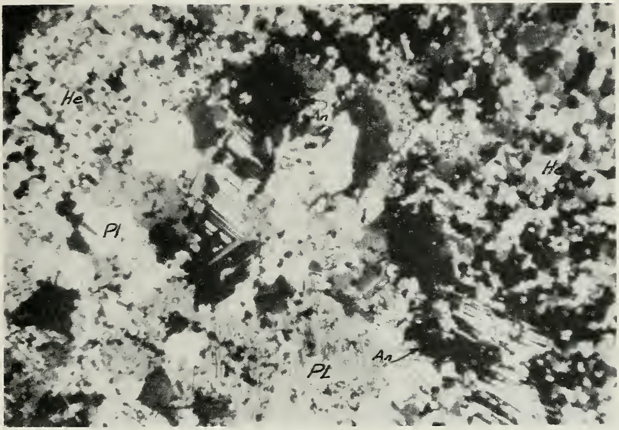

FIG. 29. Photomicrograph. Hedenbergite-andradite-plagioclase skarn, showing twinning in the plagioclase feldspar. Crossed nicols. X 23. Pl—plagioclase feldspar, An—andradite garnet, He—hedenbergite.

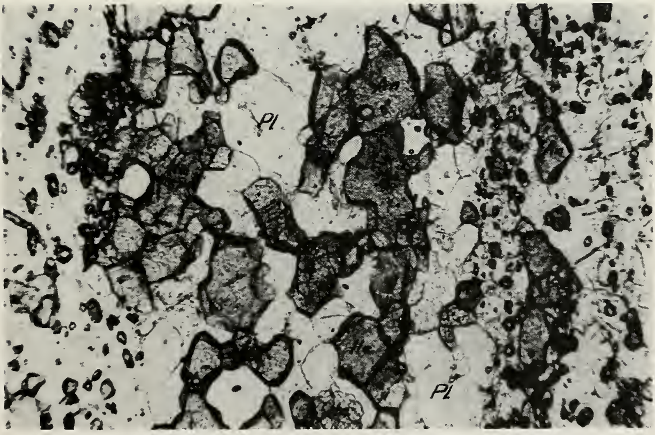

FIG. 30. Photomicrograph. Hedenbergite-andradite-plagioclase skarn. Ordinary light. X 50. Pl—plagioclase feldspar, He—hedenbergite, An—andradite garnet.

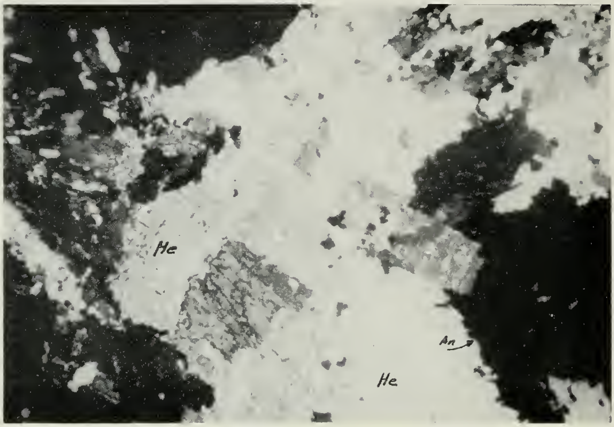

FIG. 31. Photomicrograph. Hedenbergite-andradite skarn, showing ragged borders of the hedenbergite crystals. The garnet is not birefringent in this thin-section. Crossed nicols. X 25. He—hedenbergite, An—andradite garnet.

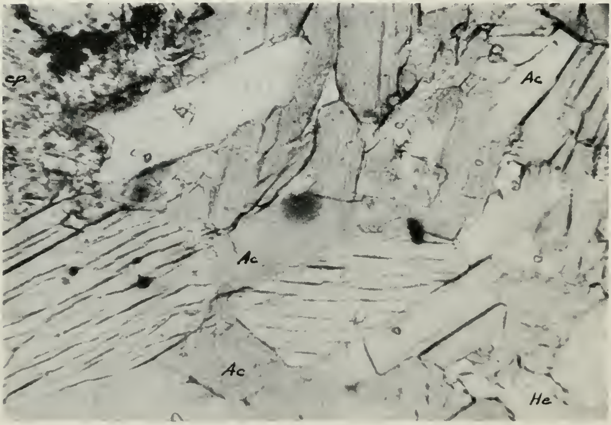

FIG. 32. Photomicrograph. Actinolite-hedenbergite-epidote rock showing texture and pleochroic halos and rings around sphene included in the actinolite. Ordinary light. X 50. Ac—actinolite, He—hedenbergite, ep—epidote.

Specific gravity for all diopsides was determined on the sensitive balance designed by Professor Berman of Harvard and the results obtained were found to range from 3.26 to 3.29.

The phlogopite is golden brown in color and occurs as isolated hexagonal-shaped crystals and also as granoblastic aggregates of hexagonal plates.

The spinel found in the Twin Lakes region is widespread and occurs as groups of disseminated crystals in the marble and as an essential constituent in the calc-silicate hornfels which occurs as zones in the marble. The spinel is found in well-developed crystals showing the octahedron (111) whose edges are truncated by the narrow faces of the dodecahedron (110). Occasionally a twinned crystal, pale-pink to pale-violet or colorless, is found. Even a few deep ruby-red crystals were found, as well as a few black crystals. They range from less than 1 mm to 3 and 4 mm in diameter. The refractive index ranges from 1.725 to 1.730; these figures correspond closely with those of spinel, whose composition is $MgAl_2O_4$.

Usually associated with the spinel are small idioblastic crystals of clinohumite. This mineral is yellowish-orange and has a vitreous lustre; the crystals are all small.

Garnet occurs in aggregates of well-developed crystals, some of which show the normal dodecahedron in combination with the trapezohedron and hexoctahedron (fig. 9). It is cinnamon to pale yellowish brown in color, and the crystals vary in size from one-third to half an inch in diameter. In cavities, the crystals exhibit glossy smooth crystal faces. The index of refraction was found to correspond closely to 1.763, and the specific gravity, as determined on the Jolly balance by using idioblastic crystals, was found to be 3.59.

There is only one small occurrence of anorthite feldspar, and this is near the eastern end of the crystalline limestone body at Twin Lakes. The crystals are not large and occur as well-developed individuals growing out from cavity walls in a pale pinkish-gray fine grained hornfels.

Some of the minerals found in the marble may represent products of thermal metamorphism on impure clay-like clots or streaks in the original limestone, and the addition of material from the intruded igneous rocks.

Tremolite, which is not often found in the inner zone of contact-metamorphism because it is unstable at high temperatures, occurs in the marble (fig. 8). It was probably derived from the reaction of MgO and CaO with free silica, and formed at a temperature lower than the highest temperature of metamorphism.

The occurrence of diopside in the marble indicates yet a higher grade of metamorphism than that of the tremolite. The diopside was probably formed by the reaction of free silica on dolomitic marble. The reason forsterite did not form instead of diopside is that the original dolomitic limestone contained more than enough silica to form forsterite, allowing the lime-magnesia silicate diopside to form.

Phlogopite and clinohumite, minerals containing fluorine and the (OH) group, are characteristic of dolomitic marbles. The phlogopite is usually the most widespread of the two fluorine-bearing minerals.

Material from the igneous intrusion made it possible for these minerals to form. In the original limestone, there was probably not enough silica present to combine with the alumina to form aluminum silicates; as a result spinel was formed. However, the presence of the clinohumite is much more difficult to explain. It could result from the reaction of magnesium fluoride with forsterite.[3]

The formation of grossularite usually takes place in thermal metamorphism of impure non-magnesian limestone. At the locality where the garnet occurs, the crystalline limestone enclosing the garnet is of the calcite variety. This is in close agreement with the above characteristics. The presence of albite feldspar tends to indicate that there was sufficient silica present to combine with all of the alumina and form aluminum silicates and not spinel.

Brucite Marble

Brucite marble is limited in its occurrence and is not as widespread as the calcite and dolomitic marbles; it is characterized by the occurrence of small globular or spheroidal masses of brucite ($MgO.H_2O$). The rock has a granoblastic texture and the grain size is small in comparison with the other marbles. It is a close-grained, white to creamy white rock that has a specific gravity of 2.59. The brucite is in the form of irregular masses and rounded pellets. In contrast with the surrounding calcite, the brucite has low relief and appears as dull white spots in thin-sections. Under crossed-nicols, however, the brucite assumes a different character and is gray instead of white.

Forsterite occurs as an impurity in the brucite marble, and its occurrence is limited. The original magnesian limestone probably contained insufficient silica to form the double salt diopside.

During the early period of contact metamorphism, to which the original magnesian limestone was subjected, the pressure must have been low; and it was during this period that the magnesian marble was dedolomitized:

$$CaMg(CO_3)_2 + CaCO_3 = MgO + CO_2$$

Dolomite + Calcite = Periclase + Carbon-dioxide.

The resulting rock was a periclase marble. However, during the cooling of the intrusion, the periclase was hydrated to brucite and the result was a close-grained brucite marble.

Calc-Silicate Hornfels

In the body of crystalline limestone at Twin Lakes, a large portion was mapped as calc-silicate zones, which, to a large extent, are composed of calc-silicate hornfels. In the discussion to follow, all rocks influenced by contact action will be considered together, regardless of their structure.

The different forms of hornfels vary greatly in appearance, but they have similar textural relations. Some of the specimens are coarse-grained and have a distinctly granular texture; others are dense and resemble skarn rocks or tactites.

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[3] Harker, Alfred, Metamorphism, p. 125, 1933.

These rocks, on the whole, seem to lack orientation, straining, and crushing, which indicate that the calc-silicate hornfelses have not undergone noticeable amounts of regional metamorphism. The absence of such features also suggest that they were formed by contact-metamorphic action, contemporaneous with the alteration of the main body of crystalline limestone.

Wollastonite-Grossularite-Plagioclase Hornfels

Wollastonite-grossularite-plagioclase hornfels is most widespread just north of the western lake. It is dull, grayish-white in color, and because of its resistance to erosion, stands out as little crenulated and deformed ridges in the gray crystalline limestone.

The texture is granoblastic; a banded structure prevails throughout the rock. Individual bands of wollastonite alternate with bands composed of garnet, plagioclase feldspar, calcite, and sphene. The width of these bands ranges from 1 to 3 mm. Bands composed of wollastonite are much coarser grained than those of garnet and feldspar.

Wollastonite occurs abundantly in this rock as xenoblasts that average approximately 0.5 mm in length and 0.2 mm in width; it is colorless in thin-section. When fragments of the wollastonite were exposed to the rays from an ultra-violet lamp, the mineral was found to fluoresce, and then to phosphoresce a few seconds after the light was extinguished.

A colorless variety of grossularite garnet occurs as granular aggregates in bands alternating with wollastonite. These bands are not composed entirely of garnet, but contain subordinate amounts of calcite, wollastonite, and plagioclase feldspar. Under crossed-nicols the garnet is slightly birefringent; its relief is high, and equaled only by the sphene, which commonly occurs closely associated with the garnet.

Scattered throughout the rock are patches of calcite, sphene, and pyrrhotite; all of these minor accessory minerals occur in small rounded grains.

The original rock was probably an impure cherty limestone in which there was more than enough lime to satisfy the silica. Titanium from the igneous intrusion readily combined with the excess lime and formed sphene. The remaining lime recrystallized as calcite.

Spinel-Bearing Calc-Silicate Hornfels

The rocks in this group are for the most part found in the eastern part of the crystalline limestone body at Twin Lakes. They occur in narrow vein-like zones just above the trail leading from the eastern lake to Potter Pass. Similar zones occur near the eastern edge of the crystalline limestone body.

The outstanding field characteristic of these zones is their clear-cut contacts. They are bounded on all sides by coarse- to medium-grained marble which extends to the contact of the zone and ends there abruptly. There is no apparent gradation from marble to the calc-silicate hornfels zones, and the latter stand out in dike-like manner above the more easily eroded marble.

These zones of spinel-bearing calc-silicate hornfels probably represent lenses of impure material in the original limestone. Their strike is parallel to the bedding of the marble, and this fact tends to substantiate the interbedded lens-like character of the zones.

The following is a list of minerals found in the spinel-bearing calc-silicate hornfels: spinel, grossularite garnet, diopside, partasite, idocrase, phlogopite, calcite, tremolite, sphene, pyrrhotite, limonite, anorthite, acid labradorite feldspar, scheelite, and the brittle mica brandisite.

The texture of the spinel-bearing calc-silicate hornfels is granoblastic, in which porphyroblastic crystals of spinel, pargasite, and idocrase are enclosed in a granoblastic groundmass.

In the exposure of this rock near the eastern end of the crystalline limestone body, the minerals occur in zones. The innermost zone (1) is composed of a massive orange-red grossularite garnet; zone (2) is composed of green spinel, calcite, garnet, and pyrrhotite; zone (3) is composed of calcite, phlogopite, and idocrase; and zone (4) is composed of phlogopite and idocrase (fig. 11).

Spinel occurs in idioblastic crystals ranging from 0.5 to 5 mm in diameter (fig 28). It is usually colorless in thin-section but in the hand-specimen it is pale green, dark blue-green, almost black, pale pink, pale violet, and ruby-red. Crystal forms usually show the octahedrons (111), whose edges are truncated by dodecahedrons (110).

Occasionally a twinned crystal is seen which follows the spinel law. Under crossed-nicols the spinel is slightly birefringent and a faint plaid effect is produced. Frequently a crystal of spinel is found that contains numerous granular inclusions of diopside.

Grossularite garnet occurs in brown masses with no crystalline forms exposed. The diopside is colorless in thin-section, but has a faint pinkish tinge when viewed in the hand-specimen. It occurs in both xenoblastic and idioblastic crystals which range from 0.1 to 1 mm in diameter.

Pargasite is limited to two zones. One outcrops above the trail leading from the eastern lake to Potter Pass; the other outcrops not far from the same trail near the eastern edge of the crystalline limestone body (fig. 26). Some idioblastic crystals of pargasite measure 1 cm along the prism. In the hand-specimen the pargasite is dark brownish-green or cinnamon-brown and in thin-section it is pale green to pale brown and colorless. A spectrographic analysis of the pargasite by Dr. T. G. Kennard shows the following:

Large amount XX.XX%	Calcium Magnesium Aluminum Silicon
Small amount X.XX%	Sodium Iron
Very small amount 0.X%	Potassium Titanium Lithium Barium Strontium Copper Chromium Gallium Manganese Lead Vanadium

The presence in the spinel-bearing calc-silicate hornfels of such minerals as fluorine-bearing phlogopite and hydroxyl-bearing idocrase indicates the addition of material from an outside source, as does the mineral scheelite. The original rock was probably an impure magnesian limestone or calcareous sediment in which there was sufficient alumina to form pargasite and spinel. The vapors emanating from the igneous intrusion reacted with the impure calcareous sediment and formed phlogopite, scheelite, and idocrase.

Grossularite-Plagioclase-Diopside Hornfels

The main part of the calc-silicate zone is made up of a grossularite-plagioclase-diopside hornfels. The texture is essentially granoblastic and porphyroblastic, in which porphyroblasts of grossularite garnet are enclosed in a granoblastic groundmass of diopside, clinozoisite, zoisite, plagioclase feldspar, orthoclase feldspar, quartz, and calcite. The grain size is uniform and seldom exceeds 3 mm.

Garnet, when occurring as porphyroblasts, forms somewhat irregular crystals measuring 6 mm. in diameter. Some of the garnet, however, does not occur as porphyroblasts, but as an important part of the groundmass, forming granular aggregates with the other minerals in the rock.

Phlogopite is abundantly distributed in the spinel-bearing calc-silicate hornfels. It occurs in the form of microscopic crystals and as large pseudohexagonal crystals intergrown with anorthite. In thin-section it is pale brown to colorless, and in the hand-specimen it is golden brown to pale greenish-brown.

Idocrase is also widespread in its occurrence. At one of the pargasite localities it occurs replacing plagioclase feldspar. In the hand-specimen it is pale, greenish-brown; in thin-sections it is colorless. The crystals, some of which are half an inch in diameter, practically all show good development.

The occurrence of anorthite is an indication of a high degree of metamorphism. Only one small exposure of this mineral was found, and this particular outcrop occurs in the easternmost zone of the calc-silicate hornfels. Here the anorthite occurs as an essential constituent of the fine-grained hornfels; and in small cavities where the mineral has had an opportunity to develop freely, crystals have developed which show the following forms: (100), (010), (001), and (111).

Acid labradorite is in the rock with the pargasite. Secondary alteration has set in, and a large part of the feldspar has been altered to sericite and kaolin.

Small radiating fibers of tremolite occur in this rock, especially in those hornfelses containing an abundance of pargasite.

Of special interest is the occurrence of brandisite. This mineral is limited to the anorthite locality in the easternmost calc-silicate hornfels. It occurs in pale-greenish pseudohexagonal crystals which measure 5 mm in width and 1 mm in thickness.

Calcite, sphene, pyrrhotite, and limonite are the minor accessory minerals. Calcite can be found in irregular patches, and sphene and pyrrhotite occur as rounded grains.

In the hand-specimen the garnet is pale brown. However, in thin-section it is colorless and slightly birefringent. Twinning is occasionally found. Inclusions of such minerals as diopside, calcite, and pyrrhotite are common and the presence of these minerals seems to indicate that the garnet was formed later than the included minerals.

Both orthoclase and plagioclase feldspar are in this rock. The former is the more abundant and is usually in granular aggregates with quartz, calcite, diopside, and plagioclase feldspar.

Colorless diopside is widespread in the grossularite-plagioclase-diopside hornfels. The usual habit of the diopside is granular aggregates with the other minerals. Accompanying the diopside are small amounts of pale-green hedenbergite.

Some large crystals of clinozoisite measure 2 to 3 mm in length, and are somewhat idioblastic. From the optical data it was concluded that the mineral is not the pure molecule clinozoisite but a mixture containing 93 mol percent clinozoisite and 7 mol percent epidote. The mineral is colorless in thin-section, but under crossed-nicols it exhibits beautiful ultra-blue and yellow abnormal interference colors.

Zoisite occurs closely associated with the clinozoisite and at times it is difficult to distinguish between the two.

The minerals present in small amounts are quartz, calcite, sphene, idocrase, scapolite, and pyrrhotite. The sphene occasionally occurs in well-formed crystals; the quartz and calcite occur in irregular patches and as granoblastic aggregates with the feldspar and other constituents.

Idocrase and scapolite are limited in occurrence and were found only in one single outcrop located near the outlet of the western lake. The idocrase is pale pinkish-orange. The crystals are xenoblastic and enclose scapolite crystals so small that determination of their mineralogical characteristics is difficult.

The explanation of the origin of the grossularite-plagioclase-diopside hornfels is problematical. The original rock was probably an impure calcareous sediment containing an abundance of aluminum and siliceous materials. However, the absence of spinel and the presence of quartz indicate that there was more than enough silica to promote the formation of the various aluminum silicates. The association of free silica and calcite in the rock seems to indicate incomplete equilibrium or a low grade of metamorphism. The appearance of potash feldspar marks an advanced grade of metamorphism, as does also the lack of members of the amphibole group.[4]

Skarn

In the southwestern tip of the crystalline limestone body at Twin Lakes there outcrops a small deposit of skarn.[5]

Skarn is economically the most important rock type in this region, since in some places it contains the mineral scheelite. There are three types of skarns present. In the order of their abundance they are as follows:

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[4] Harker, Alfred, Metamorphism. p. 94, 1933.

[5] "Skarn—An old Swedish mining term for the silicate gangue (amphibole, pyroxene, garnet. etc.) of certain iron ore and sulphide deposits of Archean age, particularly those which have replaced limestone and dolomite. The term is used in this sense by Fennoscandian geologist, but it has been extended to cover analogous products of contact metamorphism in younger formations." Holmes, A., The Nomenclature of Petrology, (London, 1920), p. 211.

1. Hedenbergite-andradite-plagioclase skarn (fig. 29).
2. Hedenbergite-andradite skarn (fig. 31).
3. Hedenbergite-magnetite skarn.

The three types differ only in mineralogical composition, and are therefore described as a single rock with individual modifications.

The skarn is composed essentially of hedenbergite, andradite garnet, plagioclase feldspar, and magnetite, plus minor amounts of zoisite, calcite, sphene, epidote, and quartz. The texture is granoblastic; the grain size is medium to small, except in the case of the hedenbergite-andradite skarn, where the grain size varies from medium to coarse.

The hedenbergite constitutes a large percent of the rock; it is green in color and contains less than 5 percent of the diopside molecule.

The garnet is a fairly pure andradite; it has a specific gravity of 3.75 and an index of refrection greater than 1.81; it is pale brownish-red, and is usually found in irregular and xenoblastic grains.

A plagioclase feldspar, which corresponds closely in composition to basic labradorite, occurs in large poikiloblastic crystals in the skarn. This mineral is fresh and has been subjected to little or no alteration. Albite is the characteristic type of twinning, although carlsbad twinning is not entirely absent.

Magnetite, of all minerals present, is most variable in distribution. In some of the skarns it is present in only minor amounts, while in others it is so abundant as to form a skarn known as hedenbergite-magnetite. However, in all occurrences it forms irregular patches and xenoblastic crystal grains. In the hedenbergite-andradite skarns it occurs as an interstitial material between the hedenbergite and andradite. When present with plagioclase feldspar, it can be found as inclusions in the feldspar. In the hedenbergite-magnetite skarn it forms an essential constituent, and is intercrystallized with the hedenbergite.

Occasionally an idioblastic crystal of sphene occurs. The quartz and calcite are both variable in their occurrence and amount.

The zoisite (beta-zoisite) is also variable in occurrence. In ordinary light the zoisite is colorless, but under crossed-nicols, it shows ultra-blue abnormal interference colors.

Scheelite occurs at several small places in the skarn deposit; one is near the northern end of the deposit where the skarn appears to be made up essentially of hedenbergite-andradite-plagioclase and minor amounts of magnetite. Many of the scheelite crystals are rather large and measure to 0.5 cm in diameter.

The structural relationships indicate that the magnetite may have been introduced along fractures which acted as channels for the migration of vapors containing iron. The iron may, however, have been introduced as a liquid solution at a later stage. The pegmatites cutting the skarn contain little or no magnetite; therefore, they may have been injected subsequent to the formation of the magnetite. It is possible that the skarn represents metamorphism of a basic igneous rock such as an andesite. The presence of actinolite-hedenbergite-epidote rocks associated with the skarn tends to indicate strongly origin by contact metamorphism. Also, the presence of scheelite in both the skarn and the actinolite-hedenbergite-epidote rocks points toward contact metamorphism.

Actinolite-Hedenbergite-Epidote Rocks

Included in the skarn deposit are two narrow lens-shaped bodies of actinolite-hedenbergite-epidote rock which are separated by a narrow zone of skarn and epidote rock.

The actinolite-hedenbergite-epidote rock is composed essentially of actinolite, hedenbergite, epidote, and minor amounts of magnetite, sphene, and quartz. The texture is somewhat variable. A banded structure prevails throughout the deposit and the individual bands are composed of large radiating crystals of actinolite. The grain size ranges from needles and blades less than 1 mm in width to large crystals 1.5 cm to 5 and 8 cm in length.

The actinolite is dark green in the hand-specimen and pale bluish-green in thin-section. It shows distinct pleochroism in shades of pale yellowish-green and pale bluish-green (fig. 32).

The hedenbergite, which occurs somewhat subordinate to the actinolite, has the same properties as in the skarn. Here, however, it is much better developed than in the skarn, and the following crystal forms are present: (100), (110), and (010).

Sphene, the main accessory mineral, occurs scattered throughout the rock with an occasional accumulation in some large crystals of actinolite. Most of the sphene that occurs as inclusions in the actinolite is surrounded by dark, greenish-brown pleochroic halos, which change from pale greenish-brown to dark greenish-brown as the stage of the microscope is turned through 360°. The halos assume, to a certain degree, the shape of the sphene grain, and the best developed halos are circular in shape.

The magnetite and quartz are usually very closely associated in little veinlets and irregular-shaped masses. The occurrence of quartz in this manner is important because it indicates that the silica was added to the rock from an outside source. Occasionally a small cubic crystal of magnetite is found included in the actinolite.

Epidote Rock

Situated between the actinolite-hedenbergite-epidote rock and the skarn there is a narrow zone of epidote rock. It has a pistachio-green color and a fine-grained texture. The grain size averages not less than 1 mm. Minor amounts of grass-green actinolite in slender needles can be found in this rock.

In the transition rock, intermediate between epidote rocks and actinolite-hedenbergite-epidote rocks, are minor amounts of calcite, quartz, chlorite, andradite, and hedenbergite. The chlorite shows abnormal interference colors such as ultra-blue, brown, and violet.

These rocks were probably formed by the combined processes of regional and contact metamorphism of basic igneous rocks, probably lava flows. In the metamorphic processes, the original feldspar was destroyed and epidote was formed from it.

Pyroxene in the original rock was probably the source of the later actinolite. Granular sphene represents either recrystallized sphene or a metamorphosed ilmenite.

Pegmatites of the Skarn Deposit

The pegmatites which cut the skarn deposit had little or no effect on it. The contacts between the pegmatites and the skarn rocks are everywhere distinct.

The mineral composition of the pegmatites is variable. The minerals include microcline, oligoclase feldspar, quartz, almandine garnet, epidote, and minor amounts of magnetite. One pegmatite was found to contain at least 90 percent epidote.

Occasionally miarolitic cavities are found containing well-developed crystals of epidote and microcline (fig. 16). In all of the thin sections of the pegmatites, the plagioclase feldspar was altered to sericite, but the microcline was fresh and unaltered. The hedenbergite of the skarn in contact with the pegmatite is partly altered to chlorite, but does not penetrate any great distance into the skarn.

The above relations indicate that following the emplacement of the pegmatites, aqueous emanations acted upon the plagioclase feldspar and hedenbergite and formed sericite and chlorite.

The total effects of the pegmatites on the skarn are limited and concentrated along the immediate contacts. The origin of the skarn may be attributed to dynamo-thermal, contact metamorphism, and metasomatism, acting together or independently.

CONCLUSION

The assemblage of rocks in the Twin Lakes region is exceedingly variable in so far as rock types and mineralogical composition are concerned.

The pre-Cretaceous sediments and associated pre-granitic igneous rocks were subjected to at least two distinct periods of metamorphism: (1) an earlier dynamo-thermal metamorphism; and (2) a later contact metamorphism. Of these two, the second exerted the more profound effect, nearly obliterating the effects of the first. The action took place in the mesozone.

The processes of contact metamorphism involved the addition of material as well as recrystallization of the original rocks. Additive metamorphism is exemplified by the presence of the minerals scapolite, idocrase, phlogopite, clinohumite, tourmaline, and scheelite.

The effects of metamorphic action on intrusive igneous rocks (known as endomorphism) are not pronounced. In the vicinity of the skarn deposit one can find occasionally a thin veneer of epidote and garnet coating the intruding igneous rock. A study of the thin-sections shows that the epidote was derived from the plagioclase feldspar and the garnet from the ferromagnesian minerals, with possible addition of material from the plagioclase. These effects are, however, limited to a zone not more than a quarter of an inch in thickness.

SCHEELITE MINERALIZATION

In the Twin Lakes region there are two distinct occurrences of scheelite. The larger (A) is in the skarn or tactite deposit near the southwestern tip of the crystalline limestone body. The smaller (B) is near the eastern end of the crystalline limestone body.

They both represent mineralization somewhat similar in many respects to other scheelite deposits as, for example, the Inyo County, California,[6] and Mill City, Nevada,[7] deposits.

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[6] Knopf, Adolph, Bull. 640, U. S. Geol. Survey, 1917.

[7] Kerr, Paul F., Geology of the tungsten deposits near Mill City, Nevada: Univ. Nevada Bull., vol. 28, no. 2, 1934.
Information Circular 6280, U. S. Bureau of Mines, 1930.

The skarn deposit, A, is a lenticular mass of contact-metamorphic rock 400 feet in length and 40 feet wide. The strike is roughly N-S and parallels closely the general strike of the nearby schists, gneisses, and quartzites.

Deposit B is vein-like, 70 feet in length and between 5 and 8 inches in width; its strike is parallel to the strike of the marble with which it is in contact.

The principal rock types at deposit A are skarns and an actinolite-hedenbergite-epidote rock, composed essentially of calc-silicates such as hedenbergite, andradite garnet, epidote, plagioclase feldspar, grossularite garnet, and actinolite. There are other minerals present, such as magnetite, calcite, and minor amounts of quartz, sphene, chalcopyrite, pyrrhotite, and scheelite. Scheelite is erratic in distribution and is localized in three separate areas. The area farthest south is exceedingly small; it is in the coarsely crystalline phase of the actinolite-hedenbergite-epidote rock. Northward the occurrences of scheelite become more distinct. Near the middle of the skarn is a small outcrop of very heavy magnetite-andradite skarn, which contains a showing of scheelite near its northern margin. The largest scheelite occurrence is situated near the northern end of the skarn; the rock is the hedenbergite-andradite-plagioclase skarn which contains small isolated concentrations of magnetite and hedenbergite. The ore-bearing rock is highly fractured and is cut here and there by numerous narrow veinlets of quartz, and several dikes of acid pegmatite. Owing to the highly fractured condition of the rock, the ore has a ''rotten'' appearance which is typical of those scheelite ores which occur near contacts between igneous and metamorphic rocks in many localities in the Sierra Nevada.

The distribution of the scheelite at deposit B is much more erratic than at deposit A. The principal rock type at deposit B is a spinel-bearing calc-silicate hornfels which shows a marked tendency toward banding or zoning. Starting at the center of the deposit and proceeding in an outward direction there are at least four zones: (1) massive orange-red grossularite garnet; (2) mixture of green spinel; calcite, garnet, and pyrrhotite; (3) calcite, phlogopite, and idocrase; and (4) phlogopite, idocrase, and minor amounts of calcite. The scheelite occurs in the intermediate phase between zone (2) containing the pyrrhotite and zone (3) containing the idocrase and phlogopite.

Origin of the Scheelite Occurrences

The two deposits in which the scheelite occurs are typical contact, or ''pyrometasomatic''[8] deposits. They owe their position and form to the structure and composition of the original calcareous sediments which were intruded by granitic rocks, and to the physico-chemical condition which existed during the period of metamorphism.

Deposit A is lenticular in shape because of its conformity with the contacts of the rocks. Deposit B is distinctly tabular, owing to the selective metasomatic replacement of a certain bed which, because of its original composition, was more susceptible to replacement than the surrounding limestone.

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[8] Lindgren, W., A suggestion for the terminology of certain mineral deposits: Econ. Geol., vol. 17, pp. 292-294, 1922.

Both deposits were formed at high temperatures by emanations given off from the cooling intrusive. The first minerals to form were the silicates, especially the garnets, epidote, hedenbergite, and actinolite. After the silicate minerals came magnetite, followed very closely by scheelite and the pyrrhotite, which now occupy the interstices between the earlier-formed silicates. The last minerals to form were the hydrous and fluorine-bearing minerals, idocrase, phlogopite, and chlorite, and minor amounts of calcite.

In the case of the skarn deposit (A), there were probably two distinct periods of metamorphism: (1) contact-metamorphism at the time of the intrusion; and (2) contact-pyrometasomatism shortly following the intrusion and consolidation of the intrusive rock. During the first period, garnet, hedenbergite, and actinolite were formed. The hydrous minerals, epidote, chlorite, and zoisite, and the minerals scheelite, magnetite, and pyrrhotite, were formed during the second period. Injection of acid pegmatites and quartz veinlets accompanied or followed the ending phases of the second period. In all probability calcite and quartz were the last minerals to form, since they can be found cross-cutting the earlier-formed minerals.

To summarize briefly the foregoing discussion: the scheelite occurrences at Twin Lakes were formed by metasomatic replacement of calcareous sedimentary rocks, and by the addition of materials which entered as emanations from the invading igneous rock, quartz diorite.

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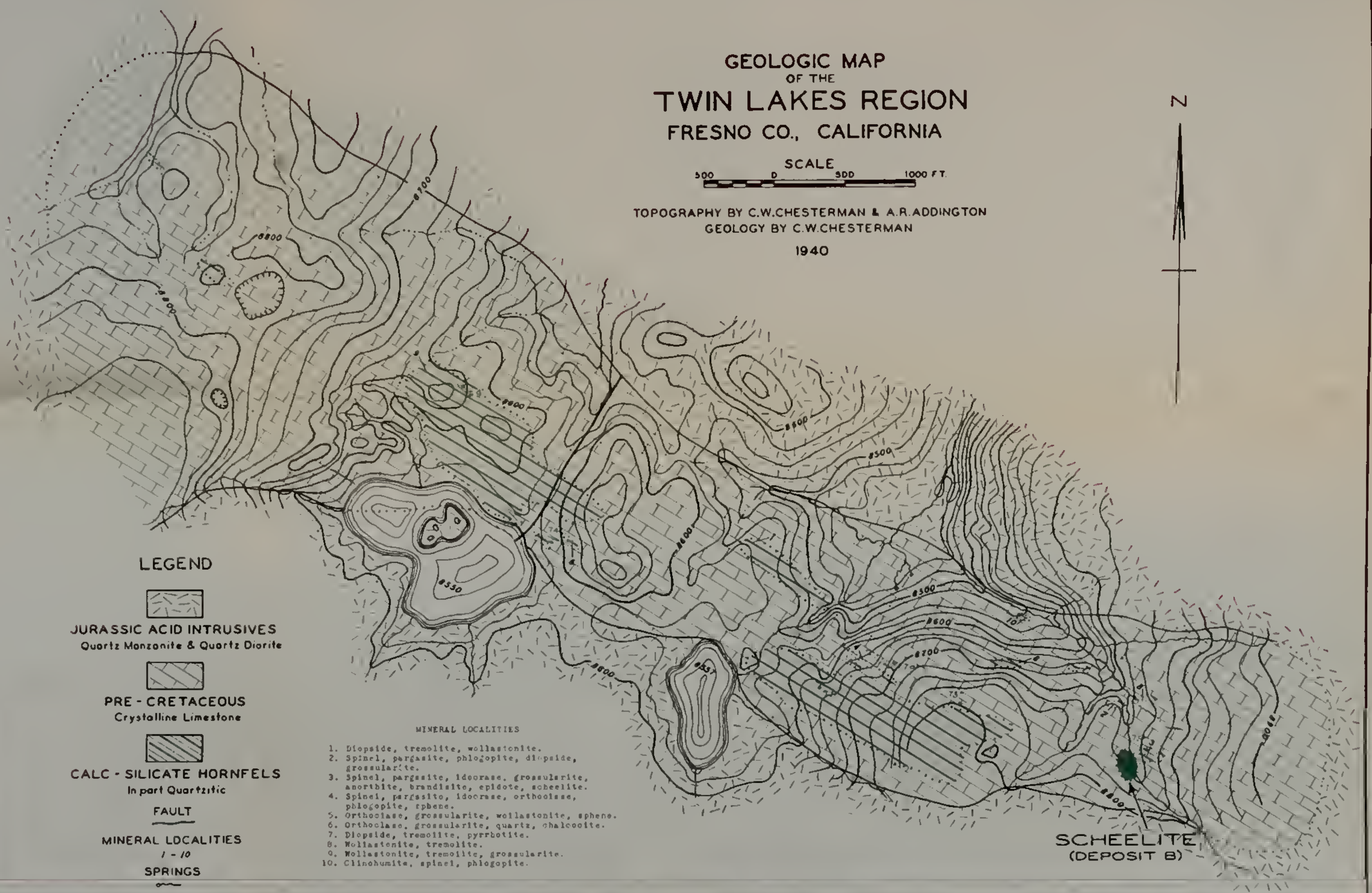
PLATE VII



GEOLOGIC MAP
OF THE
TWIN LAKES REGION
FRESNO CO., CALIFORNIA

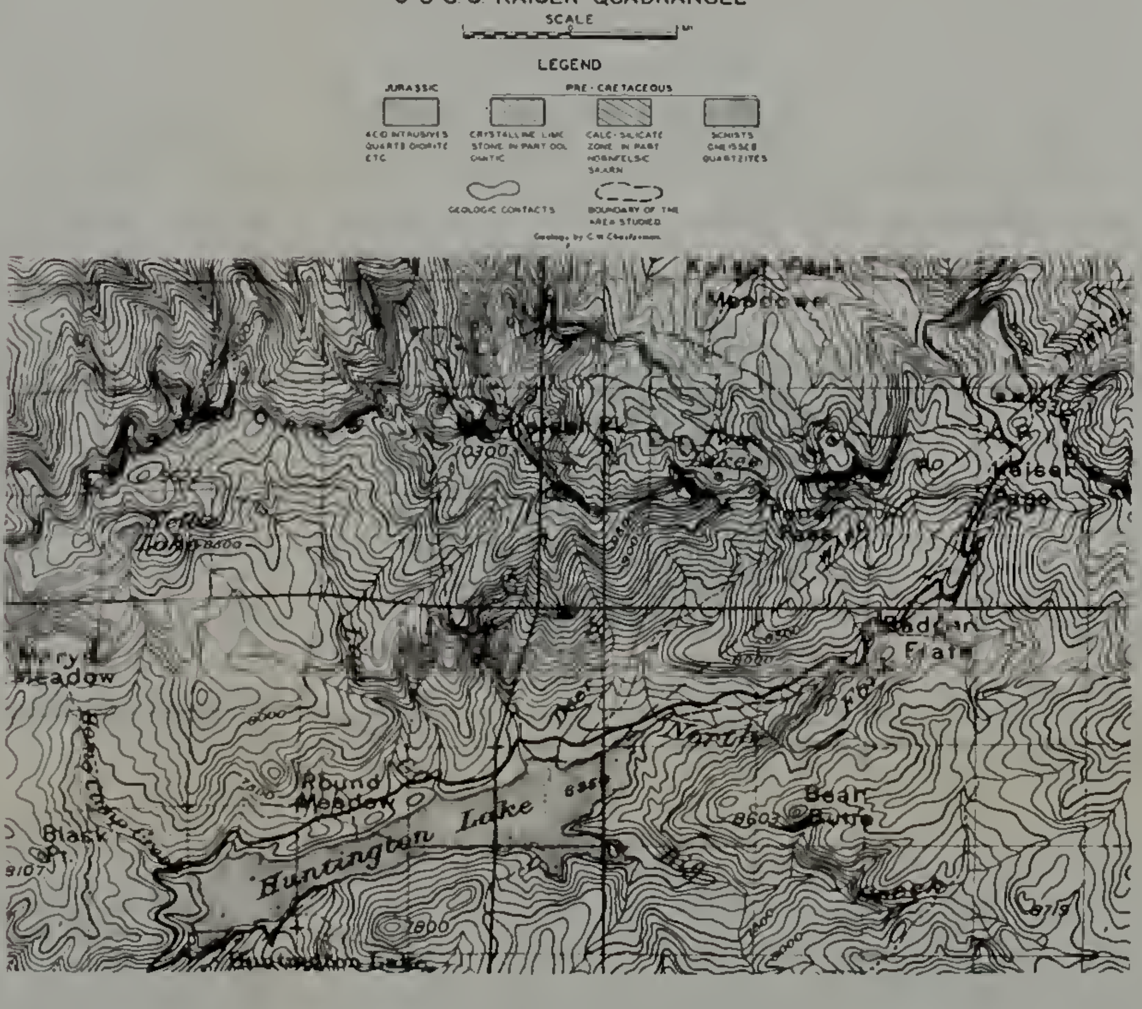
SCALE
500 0 500 1000 FT.

TOPOGRAPHY BY C.W.CHESTERMAN & A.R.ADDINGTON
GEOLOGY BY C.W.CHESTERMAN
1940

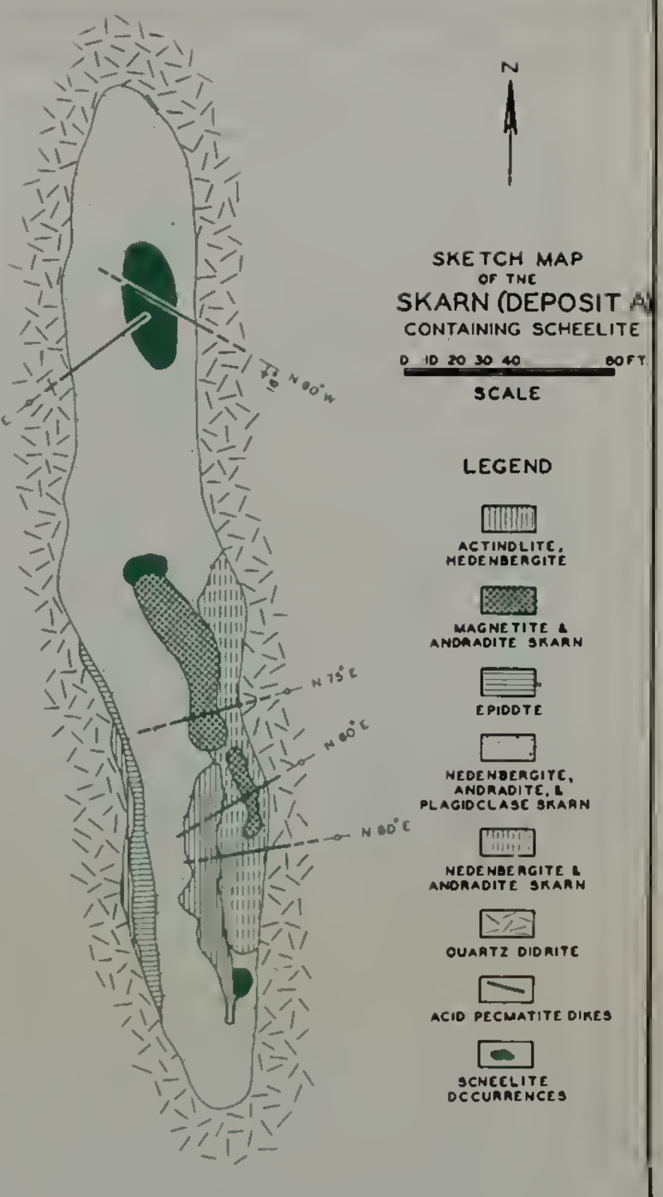
MINERAL LOCALITIES

1. Diopside, tremolite, wollastonite.
2. Spinel, pargasite, phlogopite, diopside, grossularite.
3. Spinel, pargasite, idocrase, grossularite, anorthite, brandisite, epidote, scheelite.
4. Spinel, pargasite, idocrase, orthoclase, phlogopite, sphene.
5. Orthoclase, grossularite, wollastonite, sphene.
6. Orthoclase, grossularite, quartz, chalcocite.
7. Diopside, tremolite, pyrrhotite.
8. Wollastonite, tremolite.
9. Wollastonite, tremolite, grossularite.
10. Clinohumite, spinel, phlogopite.

TOPOGRAPHIC & LOCATION MAP
U S G S KAISER QUADRANGLE



SCALE
LEGEND
JURASSIC
PRE-CRETACEOUS
ACID INTRUSIVES QUARTZ DIORITE ETC
CRYSTALLINE LIME STONE IN PART DOLOMITIC
CALC-SILICATE ZONE IN PART HORNFELSIC SKARN
SCHISTS GNEISSES QUARTZITES
GEOLOGIC CONTACTS
BOUNDARY OF THE AREA STUDIED
Geology by C.W.Chesterman
Meadow
Kaiser Pass
Badger Flats
Round Meadow
Huntington Lake
North
Bear Butte
Big Creek
Black Pt.
Huntington Lake



SKETCH MAP
OF THE
SKARN (DEPOSIT A
CONTAINING SCHEELITE

ACCOMPANYING STATE MINERALOGIST'S REPORT XXXVIII, JULY-OCTOBER, 1942

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TUNGSTEN DEPOSITS OF THE CONFIDENCE MINING DISTRICT, TUOLUMNE COUNTY, CALIFORNIA

By James M. Little *

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INTRODUCTION

The scheelite deposits described in this report lie on the west slope of Mount Lewis, in the Stanislaus National Forest, 1¾ miles by air-line from Confidence, Tuolumne County, California. The southwest end of the mineralized area is accessible by a dirt road, 3½ miles in length which leaves the paved highway (State Highway 108) from a point ½ mile east of Confidence, and runs south, down into the deep canyon of the North Fork of the Tuolumne River. In the winter rainy season this road is impassable.

On the accompanying map, the occurrences of scheelite in the area are shown by numbers (1 to 9). The area including these localities represents a zone of mineralization which trends northeast-southwest. The total difference in relief between Mount Lewis and the river is 2500 feet. One escarpment in particular, makes the area very difficult to approach from the east.

There are no extremes in climate at this low altitude and snow usually remains only a few days.

The properties have forests containing ponderosa and sugar pine, red and white fir, black oak and live oak. A small stream of water flows in Johnnie Gulch throughout the summer.

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* Mining Engineer, Tuolumne, California. Report dated February 10, 1942. Manuscript submitted for publication September 21, 1942.

DESCRIPTION OF THE ROCKS

General Features

The general geology of the region is described in U. S. Geological Survey folios No. 51 (Big Trees) and No. 41 (Sonora). The Confidence Mining district is situated in the southern part of the Big Trees quadrangle.

The rocks exposed on the surface and described in the folios consist of the following: (1) the Calaveras formation (Paleozoic in age) consisting of argillite, limestone, quartzite, and schist; (2) granodiorite (commonly called granite) which is a part of the large batholith of the Sierra Nevada and which in this district manifests itself in a large embayment, or intruding arm, 4 or 5 miles in width, bulging towards Sonora to the west, separating the Calaveras formation into segments, and extending southward for several miles. This geologic feature is clearly shown on the 1938 Geologic Map of California.

The intrusion of this granite, which took place in late Jurassic time is the most important structural feature of this area. Accompanying the cooling of the granite at depth and following its solidification, fissures of no apparent displacement were formed and impregnated with quartz-vein mineralization by hot solutions emanating from the granite.

Subsequent to this mineralization no important disturbance seems to have taken place, since the contacts and veins are not offset by post-mineral faulting.

Calaveras Formation

The Calaveras formation consists of meta-sedimentary rocks (in this area principally quartzite, limestone, and schist) whose strike follows the northwest-southeast course of the mountain range. This formation is frequently interrupted by large masses of granite. In the Confidence Mining district the belt of meta-sedimentary rocks is 19 miles wide. Its western boundary is along the Mother Lode; its eastern boundary is 1 mile east of Mount Lewis. The western portion of Calaveras formation is described as a steeply dipping complex series of slates, schists, and other metamorphic rocks. At a time earlier than the granite intrusion (though still in the Upper Jurassic), basic and medium basic igneous rocks were intruded into the sediments of both Paleozoic and Jurassic age. A profound mountain-making disturbance (called the late Jurassic Nevadan orogeny) followed the time of the basic intrusions; all the rocks were folded and then injected by granite. Metallic mineralization (principally gold) followed the intrusion of the granite. Scheelite mineralization appears to be associated with this period of mineralization.

Limestone: The limestone of the Calaveras formation in this area has a width of 1½ miles. It is in this limestone, and in the schist derived from it, that the deposits of scheelite occur. The schistose phase of the limestone occurs usually in small areas, particularly along steeply dipping contacts with granite. Shearing appears to be associated with contraction of the granite during cooling.

The limestone beds usually dip about 40° northeast. The lower horizons are interbedded with less calcareous beds and shale. The uppermost horizon, adjacent to the quartzite on Mount Lewis, is a tough, massive, thick-bedded, blue, fairly pure limestone, several hundred feet in thickness. Scheelite ore occurs in this purer limestone.

Quartzite: Quartzite is the top horizon of the Calaveras formation in this area, and it rests conformably on the limestone. It is a typical hard, erosion-resistant, white quartzite and it forms the summits of Mount Lewis (5474 feet elevation) and of most of the highest peaks and ridges in the surrounding country. Relatively few of the gold-quartz veins penetrate far into it, and the writer knows of none that have produced any ore. It appears to be unfavorable to metallic mineralization, and none of the scheelite showings were found in it.

The northern portion of the limestone-quartzite contact shown on the map is a fault contact.

Granite

The commonly applied term ''granite'' is used here for the granitic rock formation that forms the great batholith of the Sierra Nevada. This widespread formation varies somewhat in its character but it is most commonly a granite or a granodiorite. In the area mapped, the main mass is probably chiefly a granodiorite. More basic segregation phases occur locally along contacts with limestone and with quartzite; especially as sills and dikes in the limestone near contacts. This more basic phase was observed near a scheelite deposit, *No. 4,* but no particular effect on the ore occurrence was noted.

GOLD-BEARING QUARTZ VEINS

The California Gold Belt quartz veins present similarities in many features and it is believed that all were mineralized during the same period, following the granite intrusion. This does not imply that the rock fracturing which formed the pre-mineralization fissures was always due to the same cause.

The gold-quartz veins belong to the intermediate temperature or mesothermal deposits of Lindgren's classification.

The Mother Lode strikes northwest-southeast and dips steeply northeast. Twelve miles to the northeast of the Mother Lode is found a system of veins that parallel the Mother Lode in both strike and dip. This vein system is commonly known as the Mother Lode East Belt, and includes the Dead Horse, New Albany and other veins near Tuolumne, and the Belleview vein to the northwest. Since the Mother Lode and the East Belt veins strike parallel to the main structural features of the Sierra Nevada, this fissuring is probably a later result of the folding and faulting. Moreover, these veins usually occupy fissures along which there had been earlier fault movement, as for example the Mother Lode.

Most of the veins in this east portion of the Gold Belt, however, do not parallel the Mother Lode. Instead, many of them parallel some steep contact of the granite with the Calaveras formation. Thus the Soulsbyville vein is aligned with the granite-limestone contact along the foot of Mount Elizabeth, 2½ miles northwest of Confidence. Some veins, however, are not oriented with any known geologic feature.

The northeast-southwest veins shown on the accompanying map are roughly parallel to the main trend of the granite-limestone contact and they are most abundant near the contact. Many veins were not mapped and many or most of those shown actually continue farther than the map indicates. Soil covers much of the area and some areas are nearly inaccessible because of the chaparral,—growths of manzanita, chinquipin, hazel nut, and thickets of scrub live oak. Enough veins were found and plotted to demonstrate a great concentration of quartz veins across the center of the area covered by the map.

A characteristic of Gold Belt veins is that they occur in all rocks that were friable enough for fissures to form in them. In the area mapped, the veins occur in all the rocks but not in equal abundance. They appear to be most abundant in the granite, with the limestone coming next. Veins in the quartzite are infrequent. Gold has been produced in this area from veins both in granite and in limestone, but not in quartzite. Some veins occur on contacts.

The veins in the area mapped show less evidence of post-mineralization movement than many veins further west, both in ribboning and in gouge walls.

The widest quartz vein in the area is the so-called Mammoth Vein near *No. 8*, on a contact of granite with limestone, with a maximum width of 15 feet of quartz. While close association of gold with galena is a rule throughout the Gold Belt, this vein is the exception; for it carries considerable galena but less than $2.00 in gold. Most of the wider and stronger veins are very low in gold content.

The gold mine of the Tuolumne Mines Co., known locally as Layman's mine, is the only mine that has been kept unwatered and operated intermittently. The vein is a flat dipping cross vein.

SCHEELITE DEPOSITS

General Features

Scheelite deposits occur in limestone, on or near contacts with granite, and may be considered contact metamorphic, in type, classified by Lindgren as pyrometasomatic; formed at high temperature and great depth. In this area the deposits occur as interruptions in quartz veins which have been classified as mesothermal deposits. Because of the intimate association with quartz veins, the mineralization was probably principally aqueous rather than gaseous.

Of the six principal scheelite deposits in this area three occur in roof-pendants; four have one wall of granite; two are between limestone walls. Where granite forms one wall, it can be either the hanging-wall or the foot-wall; in one deposit the walls are nearly vertical. Only one deposit is along the contact of the granite embayment.

Starting at the north-east: the Tungstar, Iron King, Hunch, Lime Cap and a fifth claim not shown on the map but located between the Tungstar and the Iron King, constitute the Sivori group of unpatented claims.

The area between the Sivori claims and the Frey patented group is known as the Lucky Strike group, consisting of 6 unpatented claims. Insufficient boundaries were located in the field to plot these latter claims.

These two properties contain all of the scheelite ore outcrops known to the writer. These outcrops are designated by numbers 1 to 6 on the map. Each will be called by the name of the claim on which it is located.

No. 1. Tungstar

The Tungstar deposit outcrops along the ridge of a shoulder of Mount Lewis, in a narrow roof pendant of limestone schist, in the hanging-wall of a northwest dipping limestone-granite contact. This contact-metamorphic mineralized zone occurs where a gold-bearing fissure-type vein in granite encounters and follows the foot-wall contact of the roof pendant; but with its character changed from the fissure-type vein to the contact-metamorphic replacement type deposit. The scheelite deposit therefore occurs as an interruption in a quartz vein. This vein is one of the prominent veins of the area and was located and plotted for a length of 2 miles; the Tungstar scheelite deposit occurring near the middle of this extent. Below the scheelite deposit the vein follows a steep ridge spur down to the river, and across the river at the base of Mount Provo, at a distance of 6000 feet from the Tungstar deposit, it was formerly mined for gold by John Frey.

The Tungstar outcrop is at an elevation some 500 feet higher than that of the Iron King; the two being connected by a steep rocky trail. It is therefore less easily accessible than the other deposits.

A 30-foot tunnel follows the strike and shows a partially leached zone with scheelite, together with pyrite and pyrrhotite, with quartz, garnet, and epidote, in schist. Scheelite occurs chiefly in scattered patches of coarse crystals, but it is also disseminated, exposed in the face of the tunnel and in both of its walls. The mineralized zone is at least 6 feet wide, but there has been no cross-cutting to determine its total local width.

The outcrop, which has very little soil covering, has been cleaned intermittently for a distance of 200 feet northeast above the tunnel. The outcrop is for the most part oxidized and leached of sulphides. The ultra-violet lamp shows disseminated fine scheelite and patches of coarser crystals, over a width of about 6 feet, throughout the length of 200 feet. No work has been done to the southwest of the tunnel, therefore the total length of the ore shoot has not been determined.

No. 2. Iron King

The Iron King scheelite occurs on the contact of a sheared limestone tongue with granite, and at the intersection of two quartz veins. As in the case of the Tungstar, the quartz veins do not continue as such into or along side of the scheelite deposits, but the wider scheelite deposit takes the place of the veins. A minor pre-mineralization cross-fracture or joint-plane terminates the orebody abruptly on the east. The outcrop as shown on the plan has been completely stripped, exposing primary ore with only slight surface oxidation. The principal minerals are quartz, garnet, epidote, scheelite, pyrrhotite, pyrite, and chalcopyrite.

The ore is hard and tough and groove-sampling is difficult. No proper sampling has been made of the entire outcrop. Scheelite shows well throughout, under the ultra-violet lamp. The greatest concentrations of scheelite occur bordering the sulphide, with finer disseminated crystals beyond these borders. A chipped sample across the outcrop gave an assay of 0.78% WO_3 while a shallow groove sample gave 1.25%.

The outcrop is 50 feet long, 9 feet wide at its eastern end and 4 feet wide at its western end. Its horizontal area is approximately 400 sq. ft., which at 10 cu. ft. per ton would give 40 tons per foot of depth.

The tunnels shown on the plan were made at an early date, in search of gold ore. The open tunnel is entirely in granite. The dump of the caved tunnel is largely granite. On the top of the dump are vein quartz and unaltered, unmineralized limestone; both indicating that the ore zone cuts off on the east at that depth as does its outcrop.

No. 3. Hunch

The Hunch outcrop is 150 feet southwest of the Iron King outcrop. The scheelite ore exposure is in the bedrock bottom of Johnnie Gulch, along a steep contact of limestone with granite. This occurrence is at the edge of the main belt of limestone, rather than in a roof pendant.

The ore is hard and tough, consisting of blue limestone partially replaced, in patches, by quartz, pyrrhotite, epidote, scheelite and minor pyrite.

No. 4. Lime Cap

The Lime Cap outcrop occurs in limestone near and in the hangingwall of a quartz vein. This occurrence is not on a contact nor along any well-defined quartz vein. It occurs in an east-west shear zone, with the usual quartz with sulphide patches surrounded by scheelite, in hard blue limestone. The only work done is a 17-foot trench across the mineralized zone, about 50 feet west of the intersection of this shear zone with the strong quartz vein.

The nearby quartz vein shows a little scheelite and galena, with pyrite and quartz, but it is not ore.

This 17-foot width probably exposes all or most of the total width of the mineralization. With only a single cross-cut trench, there is nothing by which to estimate the length of the mineralization. Granodiorite outcrops to the west of the ore zone and diorite outcrops to the north, but the possible bearing of either on the ore occurrence was not apparent.

No sample has been taken of this outcrop, but judging by the ultra-violet lamp, the values are chiefly in patches and the ore appears to be of poorer grade than the previously described occurrences.

Scheelite showings *No. 5* and *No. 6* occur on the Lucky Strike property. This group of six unpatented claims occupies most of the area between the Hunch claim and the river that is not owned by the Frey estate. The names of the claims of this group are the Montezuma, Lucky Strike, Miracle, Mammoth, Little Wonder and Jack.

No. 5. Montezuma

The scheelite occurrence on the Montezuma claim is immediately alongside of a draw. Several feet of overburden have been removed by one trench showing 15-foot width of scheelite ore in limestone. This ore occurs in a steeply dipping roof pendant, along its contact with granite hanging-wall. The full 15-foot width exposed by the trench is well-mineralized; with the usual epidote, garnet, quartz, pyrite and scheelite.

Magnetometer readings gave the width of the limestone as 25 feet but the foot-wall 10 feet has not been prospected. The magnetometer gave the usual weak limestone readings for the ore zone in contrast to the higher readings for the granite; the sulphide content of the ore having no effect on the magnetometer.

Because of the soil covering, the nature of the unmineralized limestone of this roof pendant cannot be observed. The map shows a quartzite pendant outcropping 400 feet north, on the hanging-wall side. It also shows a quartzite pendant across the river 400 feet to the southwest, probably on the foot-wall side, also another 1000 feet to the east. Stratigraphically, the topmost horizon of the limestone is adjacent to the quartzite. Because of this proximity of quartzite pendants to limestone pendants (both dislocated) it is probable that the original horizon of this pendant at *No. 5* was near the top of the limestone; perhaps in its uppermost massive blue beds.

No. 6. Miracle

This scheelite showing on the Miracle claim is a small, poorly defined occurrence, within a limestone roof pendant. Two feet width of tactite occurs on the surface. No work has been done to show whether this showing is continuous or only a pocket.

This concludes the known outcrops, in place, of scheelite occurrences in this area. The remaining three occurrences are of boulders of tactite float, important only for what they may indicate as to possible extensions of the mineralized zone and where to look for other deposits.

No. 7. Little Wonder

A boulder of tactite was found in a draw on the Little Wonder claim. It lies near the southeastern limit of the zone of pendants, perhaps indicating that it has not travelled far.

Nos. 8 and 9. Tactite Float

Two-foot boulders of tactite float were found across the river, at *8* and *9*. They occur among boulders of granite. They may have come from points higher up on the hill, and their locations over contacts of limestone with granite may be merely accidental; on the other hand, they may lie close to their sources. Magnetometer readings gave contacts but no indications of pyrrhotite.

CONCLUSIONS

Scheelite ore in the Confidence Mining District, was discovered in the summer of 1941; first on the Iron King claim and within a few weeks the other discoveries were made. The Iron King outcrop had already been stripped years before, in search of gold ore, and this outcrop still remains the only one the limits of which have been defined on the surface. Recent trenching that has been done on the other outcrops gives very little information as to the extent of the deposits and even adequate sampling and assaying is lacking. This mineralized zone is in the early prospect stage and from the meager information available, no estimates can be made as to the possibilities of tonnages or grade.

The magnetometer was tried on buried contacts near the river, which gave distinctly different readings for the granite and the limestone and probably indicated locations of contacts within a few feet. It did not record any excess magnetism in ore occurrence *No. 5*. After the first day this survey was interrupted by snow-fall and it was not tried out on the upper deposits. A few specimens, only, of sulphide from outcrops *No. 2* and *No. 3* were magnetic, indicating the presence of some magnetic pyrrhotite. Whether or not the upper deposits could be traced out by this method is undetermined. There is the possibility, not yet proved, however, that magnetic pyrrhotite is present in enough deposits to make it an effective guide in thus locating extensions of ore and in locating undiscovered deposits. Magnetometer readings can be made at a rate of 100 per 8 hour shift.

Known quartz veins would be a guide in prospecting for ore, particularly in pendants.

The known deposits of scheelite ore occur in a zone 4000 feet long by 1000 feet wide. Much of the area is soil-covered, so it is to be expected that other deposits may occur within this area. The possible extension of the zone beyond to the northeast is limited from a standpoint of favorable geologic conditions. To the southwest of *No. 9,* the slope of Mount Provo is largely covered by soil, and even the main limestone-granite contact can be located only roughly, by tracing the upper edge of the limestone float. A magnetometer survey might locate this contact and also the position of other possible limestone pendants in the adjacent granite, and it would thus aid in locating sites for prospecting by trenching.

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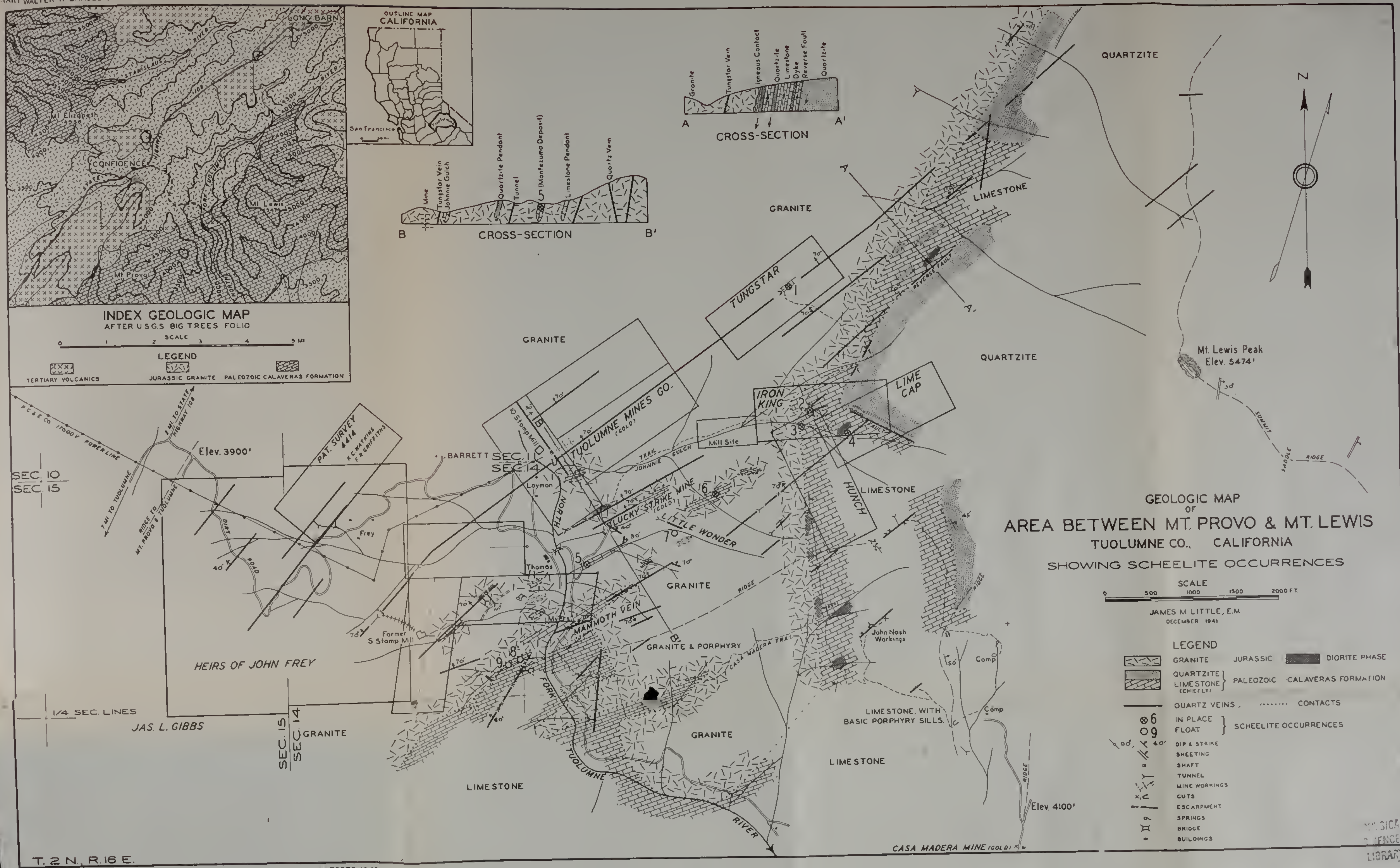
PLATE VIII



GEOLOGIC MAP OF AREA BETWEEN MT. PROVO & MT. LEWIS
TUOLUMNE CO., CALIFORNIA
SHOWING SCHEELITE OCCURRENCES

JAMES M. LITTLE, E.M.
DECEMBER 1941

ACCOMPANYING STATE MINERALOGIST'S REPORT XXXVIII, JULY-OCTOBER 1942.

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GEOLOGY OF THE WELSH TUNGSTEN DEPOSITS MADERA COUNTY, CALIFORNIA

By JAMES M. LITTLE *

OUTLINE OF REPORT

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LOCATION OF AREA

The tungsten-bearing rocks described in this report are located on the H. H. Welsh cattle ranch, commonly known as the Welsh-Kennedy ranch in O'Neal mineral district, 5 miles south of North Fork, Madera County. The topography and geology were surveyed by transit and stadia; the map covers parts of Sec. 32, T. 8 S., R. 22 E., M. D., and Secs. 3 and 4, T. 9 S., R. 22 E., M. D. For the most part, drainage is into Little Fine Gold Creek. The area lies at an elevation between 2,000 and 2,500 feet above sea level, and may be found in the southeast part of the Mariposa quadrangle of the United States Geological Survey.

GENERAL GEOLOGY

Geology of the district about North Fork has never been mapped in detail. On the Geologic Map of California (1938) granite and metamorphic rocks are shown, but many areas are left blank. The granitic rocks constitute part of the great batholith of the Sierra Nevada. The metamorphic rocks may represent sediments and igneous rocks of Paleozoic and Mesozoic time.

LOCAL GEOLOGY

Much of the area is covered by soil; rock outcrops are infrequent. As a result, the mapping of contacts between formations is not very satisfactory.

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* Manuscript submitted for publication November 4, 1942. Prospecting of the deposits was done in 1942 by the Anglo American Mining Corp. Ltd., 206 Sansome St., San Francisco, Calif., who have granted permission to publish this paper.

The following geologic features were mapped in this area:

Pre-Cretaceous, probably Mississippian
- Limestone, chiefly marble.
- Contact-metamorphic zones in limestone, containing scheelite, Contact-metamorphism and mineralization (Jurassic).
- Micaceous metamorphosed calcareous sedimentaries.

Jurassic
- Granodiorite and granite.
- Diorite, gneissoid near eastern boundary.
- Hornblendite phase of granite intrusion.
- Aplite dikes, pegmatitic when narrow.
- Quartz veins.

Metamorphic Rocks

The metamorphic rocks are subdivided locally into limestone, which is largely marble, and micaceous metamorphosed calcareous sediments. The contact-metamorphic zones in the limestone, containing scheelite, are known as tactite; these zones are designated on the map.

The metamorphic rocks in this region are remnants of non-extensive sediments which have been intruded and engulfed by later granitic rocks. The general strike of the metamorphosed sedimentary rocks is northwest. Intermittent occurrences of the metamorphic rocks continue to the southeast and cross the San Joaquin River into Fresno County. On the steep northern slope down to the river, the uptilted rocks are well exposed and consist chiefly of micaceous metamorphosed sediments and some interbedded limestone, the latter largely altered to marble.

Intrusive Igneous Rocks

Granodiorite: Granodiorite predominates regionally and occupies a large portion of the area east to the High Sierras. Likewise, it predominates westward to the lower edge of the foothills.

Hornblendite: The hornblendite sometimes appears to be younger than the granodiorite and intruded into it; other contacts between the two rocks seem to be gradational. The most basic phase is composed chiefly of amphibole with only a little feldspar; as the feldspar content increases, the hornblendite grades into granodiorite. The writer observed hornblendite only along or near zones partially occupied by sedimentaries. For instance, it is not found along the 7 miles of road and highway to North Fork, which is all through granodiorite.

Diorite: The diorite, like the hornblendite, usually forms distinct contacts with the granodiorite, but in some cases there appears to be a gradation between the two rocks. Within the area of the accompanying map the writer was unable to determine the relative ages of the major masses of these two rocks. The granodiorite dike at A, on the map, extends into the diorite to the west and so is obviously younger than the diorite.

On the map, the main contact of the diorite is with the sedimentaries. It is steep, and appears to be an igneous contact. Along this contact and to the west, well within the diorite, are gneissoid zones whose laminations parallel this main contact.

Aplite: The aplite dikes consist almost entirely of coarsely crystalline pink feldspar and quartz. Where the dikes are very narrow (a foot or two in width) they are pegmatitic in texture. These narrow pegmatitic aplite dikes appear to be very closely related to the quartz veins and it is not always easy to distinguish between the two. Moreover, instances were observed where quartz veins appear to be extensions of pegmatitic aplite dikes.

Feldspar, commonly albite, is a frequent constituent of quartz veins of the Gold Belt.

The aplite dikes are widespread in occurrence, in the region occupied by the granodiorite. Springs are frequent in the area and the several springs investigated by the writer proved to be at points where narrow aplite dikes intersected draws. The springs which supply the village of North Fork are examples. One spring is shown on the map.

Aplite dikes appear to be most abundant near sedimentary remnants. These dikes are often 5 to 10 feet wide. They evidently represent the last phase of igneous intrusion in the region.

Quartz Veins

Several quartz veins were located and plotted on the map. They are for the most part narrow and their outcrops are not conspicuous. It was impossible to trace them into some areas of deep soil and deep rock decomposition. Two miles to the west of the area examined is the Fresno Banner mine, formerly known as the Mountain View mine, now idle, with an important record of gold production. The ore occurs in quartz veins in granodiorite.

Tactite Deposits

The tactite deposits occur in limestone beds and carry a low content of scheelite, as well as garnet, epidote, quartz, and occasionally diopside. The tactites occur along or near contacts with granodiorite. A prerequisite of this contact-metamorphism is sufficient pre-mineralization fracturing, by fissuring or shearing, to admit the mineralizing solutions. Because of the deep soil cover and deep surface-rock decomposition, the relationships of these deposits to fracture-filled veins and pegmatite dikes is obscure at best. The writer is of the opinion that some, at least, of the deposits mapped occur where dikes or veins intersect the limestone formation. This conclusion is based on: (1) observations made by the writer in other regions; (2) evidence from the map; and (3) the opinion of other investigators. Where veins or dikes determine locations of ore-bearing tactite, it is evident that such veins or dikes, if they parallel the main limestone contact, are more favorable than are intersecting veins or dikes, as regards size of deposit.

Occurrences of scheelite-bearing tactite are at A, B, C and D, on the map.

Deposit A: At A the deposit is in a rib of limestone 15 feet wide. A granodiorite dike has split this limestone rib from the main limestone mass to the north, while a basic granodiorite or hornblendite dike divides it from the metamorphosed sediments to the south.

Tactite deposit A is covered with soil, so the first prospecting was by trenching. Down to shallow depth fragments of tactite float were found in the topsoil and subsoil horizons. Trenches over granodiorite were 5 feet deep, yet they bottomed in subsoil and nowhere was the granodiorite itself exposed, except for granular particles with clay. The trenches exposed harder portions of the tactite and limestone but they gave little information as to the width and nature of the tactite occurrence. They served the primary purpose of locating the deposit, for the prospecting at depth that followed.

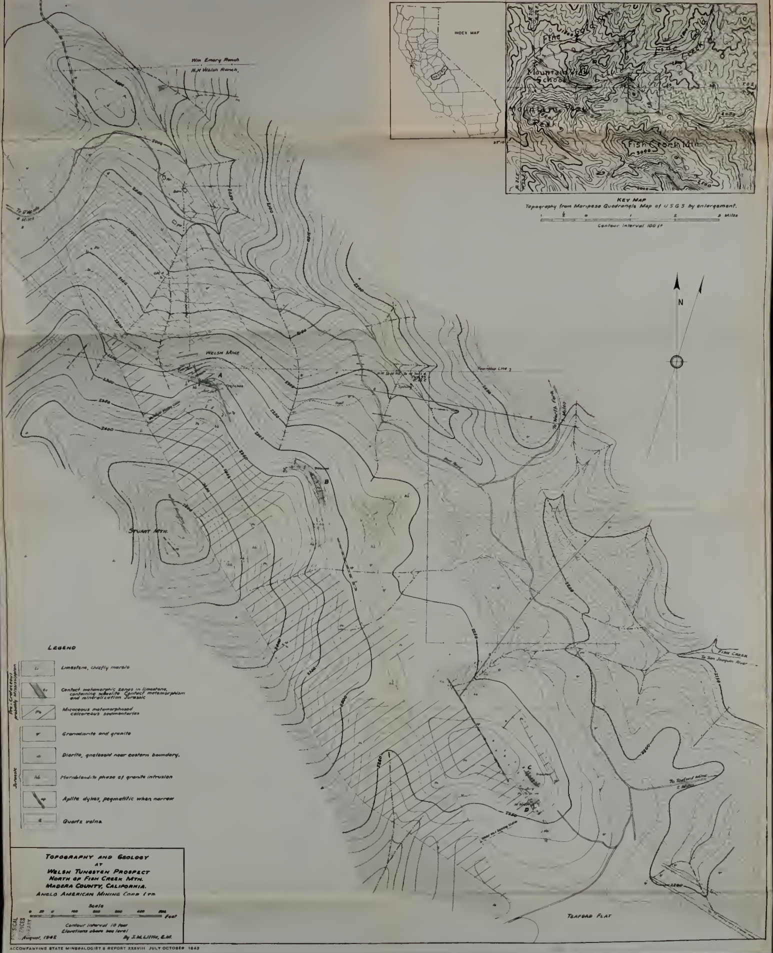
Underground prospecting at A consists of a 125-foot tunnel driven in soft, decomposed granodiorite; a crosscut through the limestone rib at 75 feet; and a second crosscut at 125 feet, which penetrates the limestone but does not extend through it. The limestone at the first crosscut is 15 feet thick and is steeply uptilted. Both walls are 3-foot, massive greenish limestone beds; the interior of the limestone rib is largely broken, thinner-bedded limestone and marble. Scheelite mineralization is scattered in patches, with garnet, epidote, and quartz, and is very low-grade. The second crosscut penetrates 5 feet into mixed limestone and very basic granodiorite or hornblendite. The limestone is partially garnetized in patches. These contain very small amounts of scheelite.

As the tunnel approaches the limestone contact, the granodiorite becomes basic. It seems probable that in this locality the hornblendite is a gradation phase of the granodiorite rather than a distinct intrusion.

Deposit B: The tactite at B occurs in a wider rib of uptilted limestone, which is composed largely of marbleized impure limestone. As shown by the map, a narrow aplite dike outcrops south of the tactite zone. This tactite outcrop was prospected by trenches only.

Deposit C: The deposit at C is a narrow rib of tactite surrounded by granodiorite. Contact metamorphism is complete and neither the horizon nor the nature of the original limestone beds is apparent. Of the four tactite occurrences, this one assays highest in tungsten.

Deposit D: The deposit at D outcrops as a shattered tactite composed of garnet, quartz, and epidote, and some scheelite. The 10-foot shaft passes out of the west-dipping tactite and bottoms in the granodiorite footwall. This deposit appears to be the extension of an uptilted marble bed which outcrops to the north.


INDEX MAP
Madera
Fine Gold
Mountain View School
Mountain View Peak
Fish Creek Mtn.
3000
2500
R 21 E
R 22 E
KEY MAP
Topography from Mariposa Quadrangle Map of U S G S by enlargement.
1 ½ 0 1 2 3 Miles
Contour interval 100 ft
N
Wm Emery Ranch
H.H. Welsh Ranch
To O'Neals
Welsh Mine
A
B
C
D
Stuart Mtn.
Township Line
Spring
To North Fork
Fish Creek
To San Joaquin River
To Teaford Mine
Teaford Flat
2200
2250
2300
2350
2400
LEGEND
Pre-Cretaceous probably Mississippian
Ls — Limestone, chiefly marble
Es — Contact metamorphic zones in limestone, containing scheelite. Contact metamorphism and mineralization Jurassic
Ps — Micaceous metamorphosed calcareous sedimentaries
Jurassic
gr — Granodiorite and granite
di — Diorite, gneissoid near eastern boundary.
hb — Hornblendite phase of granite intrusion
ap — Aplite dykes, pegmatitic when narrow
q — Quartz veins.
Scale
0 50 0 100 200 300 400 500
Feet

TOPOGRAPHY AND GEOLOGY
AT
WELSH TUNGSTEN PROSPECT
NORTH OF FISH CREEK MTN.
MADERA COUNTY, CALIFORNIA.
ANGLO AMERICAN MINING CORP LTD

Contour interval 10 feet
Elevations above sea level

August, 1942
By I. M. Little, E.M.

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GHOST CANYON TUNGSTEN CLAIMS
MADERA COUNTY, CALIFORNIA

By James M. Little *

OUTLINE OF REPORT

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INTRODUCTION

The Ghost Canyon group of mining claims, owned by John H. Walker, is located in the upper basin of the East Fork of Chiquito Creek, Madera County, in Sec. 36, T. 4 S., R. 23 E., M. D., Sec. 31, T. 4 S., R. 24 E., M. D., Sec. 1, T. 5 S., R. 23 E., M. D., and Sec. 6, T. 5 S., R. 24 E., M. D., at an elevation of 9,000 to 10,000 feet. These claims do not include the property farther south which is leased to the Walker Tungsten Mines, Inc.[1]

The Ghost Canyon claims are not at present accessible by road, the nearest road being to the Walker Tungsten Mines, Inc. To continue that road to the most important orebody, *No. 1* on the Ghost Canyon No. 1 claim, would involve considerable work in rock upon encountering the East Fork Canyon. An alternative route from the west, up Chiquito Creek, and thence across to the East Fork, would be longer but easier to construct. There are said to be deposits of iron ore between the two forks and a road to these deposits, with a branch road to the tungsten orebody on Ghost Canyon No. 1 claim is worthy of consideration.

Only a four-month work season can be counted on at this high elevation, for snow usually falls in October or November, and may not disappear before the first of June. Ordinarily, however, the work season may be as much as five, or even six, months.

The area has been glaciated, and the topography is rugged. Timber grows along Chiquito Creek almost to its head, but on hillsides the timber line is at 9,000 feet. Above this elevation, bare rock outcrops, except where talus covers parts of slopes. Absence of soil and sparseness of vegetation make prospecting easy.

GEOLOGY

General geology and known tactite deposits of the Ghost Canyon group of claims are shown on the reconnaissance map, fig. 1. The scheelite deposits have been numbered 1 to 12, inclusive. Intersections of compass bearings to landmarks formed the basis for plotting. Four of the ten claims, Ghost Canyon Nos. 1, 2, 3, and 4, could not be accurately plotted because information given in their location notices was incomplete.

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* Mining Engineer, Tuolumne, California. Manuscript submitted for publication, October 20, 1942.

[1] See fig. 1.

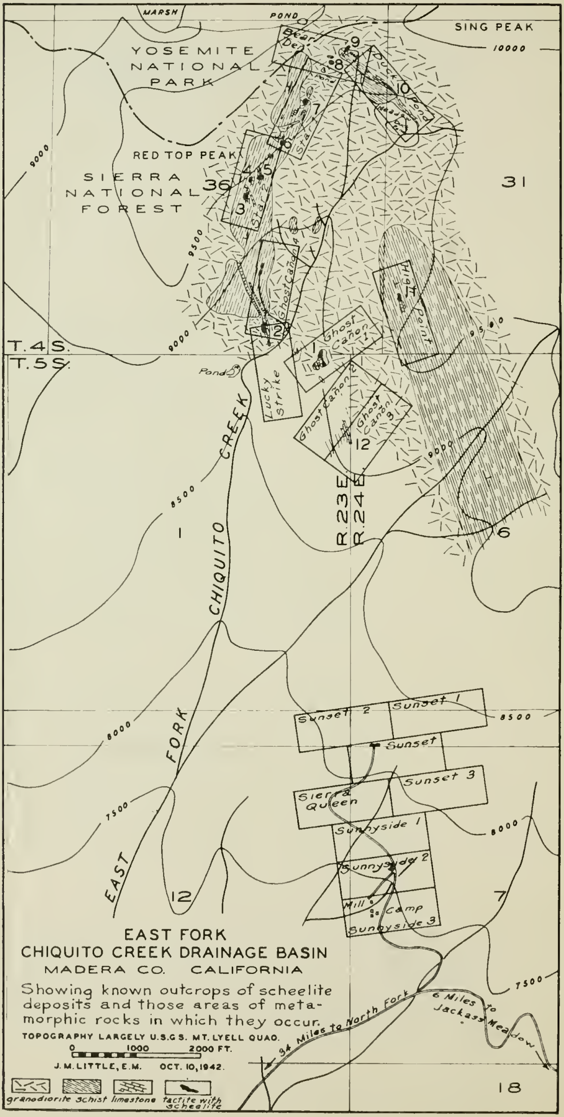

EAST FORK
CHIQUITO CREEK DRAINAGE BASIN
MADERA CO. CALIFORNIA
Showing known outcrops of scheelite deposits and those areas of metamorphic rocks in which they occur.
TOPOGRAPHY LARGELY U.S.G.S. MT. LYELL QUAD.
0 1000 2000 FT.
J. M. LITTLE, E.M. OCT. 10, 1942.
granodiorite
schist
limestone
tactite with scheelite
MARSH
POND
SING PEAK
10000
YOSEMITE NATIONAL PARK
RED TOP PEAK
SIERRA NATIONAL FOREST
Bear Den
Duck Pond
Hazard
Star
Ghost Cañon 4
Ghost Cañon 1
Ghost Cañon 2
Ghost Cañon 3
Lucky Strike
High Point
1
2
3
4
5
6
7
8
9
10
12
36
31
1
6
12
7
18
T.4S.
T.5S.
R.23E.
R.24E.
9000
9500
8500
8000
7500
Pond
CHIQUITO CREEK
EAST FORK
Sunset 1
Sunset 2
Sunset
Sunset 3
Sierra Queen
Sunnyside 1
Sunnyside 2
Sunnyside 3
Mill
Camp
3½ Miles to North Fork
6 Miles to Jackass Meadow

FIG. 1

In the granodiorite of the upper Chiquito Creek region are several pendants, erosional remnants of once extensive masses of metamorphic rock. They are composed chiefly of gray biotite schist, uptilted at various angles, usually steeply, and dipping in general outward from the center of the area. Limestone beds occur in the schist; they are usually narrow, and widely separated; they are not persistent over long distances. Scheelite occurs in tactite in these limestone beds. In the two remnants that contain scheelite showings *2* to *7* and showing *11,* the individual limestone beds are about 5 feet thick; in the small remnant that contains showings *9* and *10* the beds are somewhat thicker. The widest limestone occurs in the remnant containing showings *1* and *12.*

It will be noted that the straight course of East Fork Creek follows a line of interruption in the occurrences of the metamorphics, or remnants, and that none of the remnants are in the creek bed. In contrast to this, the wider pendants occur at higher elevations, and especially on and near ridges. It seems probable, therefore, that this creek bed bottoms the local occurrences of remnants. Since the scheelite is in these remnants, to be on the safe side, any estimates of probable continuity of ore in depth should not extend down to nearby elevations of this creek. In general, the lower of the two ends of a remnant would mark, roughly, the expected bottom elevation of the particular remnant. Very short remnants or pendants, then, are probably the last vestiges left by erosion.

ORE DEPOSITS

Contact-metamorphic ore deposits are liable to be irregular in shape and erratic in occurrence. They usually owe their existence to a combination of factors, including favorable bed horizon, the presence of a shear zone for access of mineralizing solutions, and, in many instances, proximity to an intrusive igneous source of mineralization. When any one of these factors diverges, either in the direction of strike or of dip, there is likely to be a termination of the occurrence without recurrence.

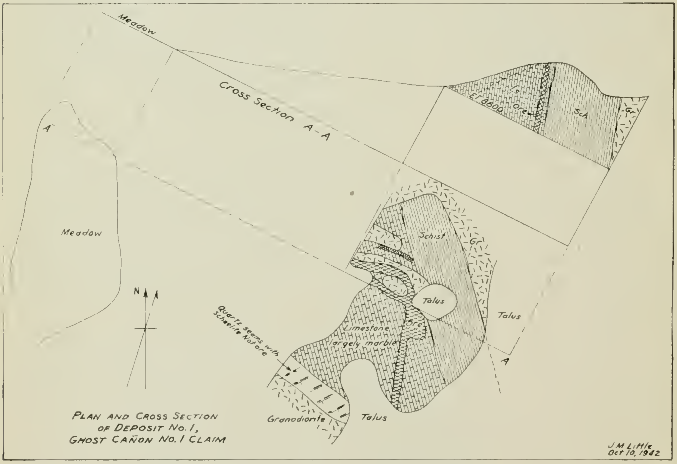
The scheelite showings on the Ghost Canyon group of claims are undeveloped. None have been opened up, so the descriptions that follow are of outcrops. Individual tactite occurrences containing scheelite are numbered from *1* to *12* on the map, figure 1. All except *Nos. 6, 10,* and *12* are shown in plan on the maps, figures 2 and 3.

The tactite deposits occur: (a) on main contacts of limestone with granodiorite; (b) within the metamorphic remnant, but adjacent to granite dikes; (c) within the remnant away from granite, with walls of schist or limestone; and (d) surrounded entirely by granodiorite, with ore sometimes occurring in the granodiorite itself. Type (d) is represented by deposit *No. 8.* Type (d) deposits are the least likely to continue in depth, as they probably are outcrops of the lowest roots of remnants and of tactite.

Outcrops such as *Nos. 2* and *7,* at the ends of narrowing pendants, are also likely to be shallow, for the same reason. Deposit *No. 7* appears to be an abrupt synclinal fold, the outcrop being double the width of the limestone stratum, which has been doubled back against itself. If this is the case, then this deposit would bottom as a trough above granodiorite at shallow depth.

Persistence of mineralization along the strike of a persistent limestone bed indicates probable continuation of ore at depth, if there is evidence that the metamorphic remnant continues at depth, locally. This condition could be fulfilled by deposits of type (c), sometimes by those of type (a). Type (b) deposits, such as *Nos. 1* and *3,* might be more erratic in occurrence, and would be less likely to maintain regularity or even persistence in depth than would deposits of types (c) and (a).

The tactite is composed chiefly of garnet, epidote, and quartz, and is usually a replacement of marble. Diopside is present in some deposits, particularly on the granite side of the contact. Sometimes replacement is incomplete. The ores are not homogeneous; scheelite occurs in patches of large and small crystals. For this reason sampling was not attempted, but the outcrops were roughly grouped as to grade of ore by means of the fluorescent lamp.



PLAN AND CROSS SECTION OF DEPOSIT No. 1, GHOST CAÑON NO. 1 CLAIM

J M Little
Oct 10, 1942

FIG. 2

The important outcrop on the Ghost Canyon group of claims is *No. 1*; and estimates of ore presented herein will be confined to this deposit. Individually, the other eleven showings represent tonnages too small to warrant construction of roads to them, or other means of transportation. Most of them are very inaccessible. However, deposit *No. 2* could be worked in conjunction with *No. 1.*

Deposit No. 1. This deposit is shown in plan and section in figure 2. It is at the northern extremity of the metamorphic remnant that contains the limestone bed of greatest width. The northern extremity of this remnant rises steeply from the talus-covered valley floor.

Irregular, steep granodiorite dikes split the marble formation, and steep-dipping tactite ore occurs adjacent to and near these dikes. Toward the south the ore follows an east-dipping fracture zone within the marble. Farther south the remnant is covered by talus consisting of large boulders of granodiorite and schist.

The scheelite occurs in garnet-epidote-quartz tactite, and appears to be most closely associated with the quartz. The ore is richest where the tactite contains the most quartz in seams and patches. There is much coarse as well as fine scheelite in this deposit.

The ore does not usually have definite walls, but the limits appear to be sufficiently abrupt to permit clean stoping of the ore.

This type of deposit is erratic, occurring as it does in connection with dike intrusions which are themselves erratic and irregular. This factor has a bearing on the vertical extent of ore that can be assumed in making a conservative estimate of probable tonnage.

The natural site for a tunnel is at the base of the escarpment, following cross-section A-A (see fig. 2), at elevation 8800. This site is at the lower, or down-slope end of the containing metamorphic remnant. Though there is some evidence from the escarpment that this lower end is steep or blunt rather than thin and feathering out, and hence that the deposit may persist at depth, the writer will assume in tonnage estimates that 8800 feet marks the bottom of the remnant, and therefore the bottom limit of probable ore; although he is of the opinion that the remnant is likely to extend below this minimum depth.

The orebody ranges in width from 5 to 10 feet, if the wider bulge near the middle, and the northernmost small, detached occurrence are ignored. The writer has assumed an average width of 7 feet. In vertical projection, there would be, above elevation 8800 feet, 36,400 cubic feet of ore in the two vertically triangular branches to the northwest, and 67,200 cubic feet of ore in the rectangular south branch; or a total of 103,600 cubic feet of ore. At approximately 10 cubic feet per ton, this would give, in round numbers, 10,000 tons of probable ore.

Estimated average grade of this ore is 1 percent WO_3.

Deposit No. 2. (See fig. 3). In its upper portion, this deposit carries good ore, probably running 1 percent WO_3. The southern portion is low in scheelite. The deposit is a mineralized limestone bed between schist and granodiorite; it disappears under talus to the north, and fails to resume beyond the talus. The outcrop is on a flat shelf above the creek, and there is no site for a tunnel.

Deposit No. 3. (See fig. 3) This small tactite deposit, with fine scheelite, does not lamp well, and has little merit. It is associated with a small granodiorite dike, and the tactite contains included granodiorite.

Deposit No. 4. (See fig. 3) Finely disseminated scheelite occurs in this deposit, in a small body of tactite. Scheelite content is low.

Deposit No. 5. (See fig. 3) This small deposit is partially garnetized limestone, and has a low scheelite content.

Deposit No. 6. This deposit consists of a limestone bed mineralized in two places by tactite containing some scheelite. The grade of ore is low, and the amount small.

Deposit No. 7. (See fig. 3) This tactite deposit forms a 15-foot high escarpment above the adjacent schist. It is an irregular mass or pod, and only its northern tip is high grade. It appears to be a replacement of an abruptly folded limestone bed, synclinal, and is probably therefore shallow. The tactite is chiefly garnet. Concentrations of scheelite occur with epidote patches.

Deposit No. 8. (See fig. 3) This deposit contains diopside with scheelite, and some granodiorite. It is surrounded by granodiorite, and probably marks the bottom of a pendant root of limestone. Rich patches of coarse scheelite occur in diopside and quartz. The ore is probably superficial, and would give way to granodiorite immediately below.

Too little underground exploration has so far been done on scheelite deposits in general, to give information on the influence of vertical horizon on the character of the ores in individual deposits. Observable evidence at the present time, of horizon influence would have to be by comparison of outcrops of deposits, one with another. This would be indirect evidence and inconclusive, since it would fail to take into account the inherent differences in the nature of individual deposits as originally formed.

Some observers of scheelite-bearing outcrops have noted that the outcropping roots of tactite deposits are often high grade: indicating that the most rapid scheelite deposition may have taken place where the mineralizing solutions first encountered the precipitating limestone. The importance of such a theory from a practical standpoint would be in its restricting the vertical range of some high-grade ores.

To the writer, deposit *No. 8* in particular suggests such a relationship between high-grade ore and first contact of mineralizing solutions with limestone.

Deposit No. 9. (See fig. 3) This deposit is in a partially garnetized marble bed which is cut off by granodiorite. The scheelite is largely in coarse crystals associated with quartz seams and patches of epidote. The grade is probably under 1 percent.

Deposit No. 10. This patch of garnet tactite, containing quartz and fine scheelite, is too small to be important. It is only about 20 feet long by 10 feet wide, judging by exploration with the fluorescent lamp.

Deposit No. 11. (See fig. 3) This regular-shaped ore stratum with schist walls is terminated abruptly toward the northwest. It is a replaced marble bed containing garnet and quartz. The grade of ore is probably about 1 percent WO_3.

Deposit No. 12. This deposit is the largest mass of garnet tactite so far discovered in the area. The main mass is fine-grained brown garnet, which completely replaces the limestone. This garnet mass showed no scheelite generally, though small amounts were found with epidote and quartz along the edge of the mass. No ore has so far been discovered at *12*.

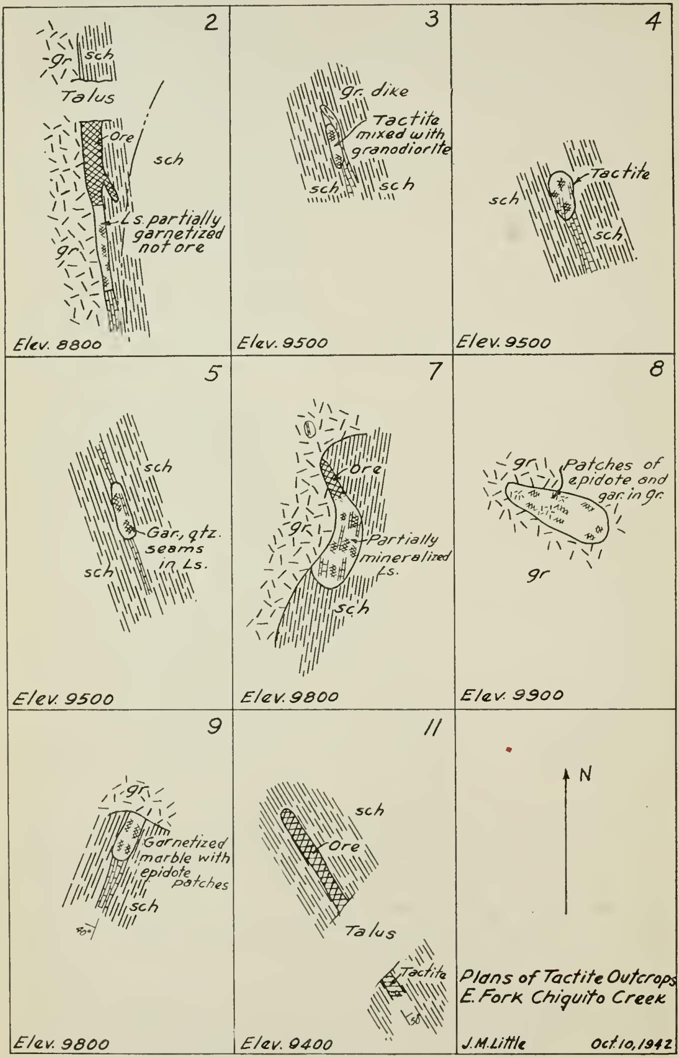

2
gr
sch
Talus
Ore
sch
Ls. partially garnetized not ore
gr
Elev. 8800
3
gr. dike
Tactite mixed with granodiorite
sch
sch
Elev. 9500
4
Tactite
sch
sch
Elev. 9500
5
sch
Gar., qtz. seams in Ls.
sch
Elev. 9500
7
Ore
gr
Partially mineralized Ls.
sch
Elev. 9800
8
gr
Patches of epidote and gar. in gr.
gr
Elev. 9900
9
gr
Garnetized marble with epidote patches
sch
40°
Elev. 9800
11
sch
Ore
Talus
Tactite
50
Elev. 9400
N
Plans of Tactite Outcrops
E. Fork Chiquito Creek
J. M. Little
Oct. 10, 1942

FIG. 3

TABULATION OF TUNGSTEN DEPOSITS OF CALIFORNIA TO ACCOMPANY ECONOMIC MINERAL MAP No. 4

Prepared under the direction of OLAF P. JENKINS *

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INTRODUCTION

Scope of Report

In the preparation of statewide mineral maps, the Geologic Branch of the California State Division of Mines has tabulated data on mineral properties so that the following essential information may be readily found: names of properties and owners; locations of deposits as regards section, township, and range; classification of the deposits as regards past production; kind of ore and type of deposit; contributor of data; and references to published works.

The following tables are prepared to accompany "Mineral Map of California, No. 4, Tungsten." This map is the fourth in a series; the first three maps, already published, are: No. 1, Quicksilver; No. 2, Oil and Gas; No. 3, Chromite. The base for these maps is the "Geologic Map of California," prepared by Olaf P. Jenkins and published in 1938, reduced in scale from 1:500,000 to 1:1,000,000; colors designating the various rock formations have been omitted from the mineral maps but the geologic boundaries and symbols appear.

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* Chief Geologist, Geologic Branch of the California State Division of Mines.

Acknowledgments

The tungsten mineral map and the accompanying tabulation represent information assembled from various sources.

In 1940 all available data of that time on tungsten deposits of California were brought together in a report by John F. Partridge, Jr., as a thesis prepared for an advanced Degree of Engineering at Stanford University. This report was published by the Division of Mines (Partridge, J. F. Jr. 41) and proved to be a great stimulus to the industry, the growth of which has been so rapid that a supplementary report became necessary. This was prepared by members of the staff of the Division of Mines soon after the first report (Tucker and Sampson 41). Since then various engineers and geologists (consultants, as well as federal and state employees) have supplied many new tungsten localities for the list. Dr. Dwight M. Lemmon of the United States Geological Survey was of special assistance in supplying much of the information which appears on the state map as well as in this list. The reassembling of the list was done by staff members of the Geologic Branch, in particular Miss Elisabeth Egenhoff. Among the contributors of unpublished data are engineers and geologists of the following concerns:

United States Geological Survey
United States Forest Service
Metals Reserve Company
Reconstruction Finance Corporation
United States Bureau of Mines
California State Division of Mines
Consultants of mining companies, in particular, The Gold Hill Dredging Company, The Anglo American Mining Corporation, and the U. S. Vanadium Corporation

Explanation of Tables

"No." in the first column of the following tables, refers to the map number assigned the property. Map numbers appear only for localities classed as A, B, or C; localities under class D are not numbered, but may be found by reference to the section, township, and range.

"Name of Claim" refers to the name which has been applied to the property; in some cases there was no record of the property name.

"Name of Owner" may be subject to change at any time.

"Location—Sec.—T.—R.—B&M" refers to the land net; in some cases it has been approximated by means of projection on available maps.

"Class by Prod." refers to the classes A, B, C, and D, based on past production. They are described on the map as follows:

A=Properties which have shipped more than 1000 short tons of 60% WO_3.
B=Properties which have shipped between 100 and 1000 tons.
C=Properties which have shipped between 0 and 100 tons.
D=Properties with no production recorded at the time the map was prepared.

"Remarks and References." In this column the kind of ore and type of ore deposit are noted briefly; citations to selected references to published works are given; in parentheses, the initials of contributors of unpublished information are given, where there are no published references. The abbreviated citations refer to the "Select Bibliography." For example, the reference to "Tucker and Sampson (41) 581" refers to an article published in the year 1941 by these authors, and to page 581 of their report. The individual contributors to unpublished data are:

L. Bryner (L B)
C. W. Chesterman (C W C)
Eldridge Drew (E D)
R. H. Elliott (R H E)
George L. Gary (G L G)
Henry G. Hubbard (H G H)
Olaf P. Jenkins (O P J)
William O. Jenkins (W O J)
Dwight M. Lemmon (D M L)
James M. Little (J M L)
George W. Rust (G W R)
J. H. Sampson (J H S)
A. W. Stickney (A W S)
W. Burling Tucker (W B T)

An attempt has been made to present authoritative information and to list all of the known occurrences of tungsten in California. Although past production has been reported in a general manner by a fourfold classification, no attempt has been made to indicate the mineral reserves of the deposits.

This list has grown steadily from its original assemblage of about 90 properties, described by Partridge (41), to about 275. The present list includes properties in the following counties:

Alpine (4)
Calaveras (2)
El Dorado (1)
Fresno (22)
Inyo (50)
Kern (53)
Madera (32)
Mariposa (3)
Mono (15)
Nevada (7)
Plumas (1)
Riverside (9)
San Bernardino (46)
San Diego (5)
Shasta (1)
Trinity (2)
Tulare (21)
Tuolumne (2)
Yuba (1)

The map and list should serve as a clearing-house for new information as it is acquired from time to time.

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TABULATED DATA

ALPINE COUNTY

NO.	NAME OF CLAIM	NAME OF OWNER	LOCATION				CLASS BY PROD.	REMARKS AND REFERENCES
			SEC.	T.	R.	B. & M.		
	Wolframite Mine (Alhambra Mine)	F. Will Keuchler (operator)	2,11	10N	18E	MD	D	Scheelite in tactite Tucker & Sampson (41)565
		Alpine Mining Co	2,11	10N	18E	MD	D	Scheelite in tactite (A W S)
	Burnside Tungsten Group	Anglo-American Co (lessees)	9,16	10N	19E	MD	D	Scheelite in tactite (A W S)
	Zaca Mine (Monitor District)	Zaca Mining Corp	31	10N	21E	MD	D	Huebnerite Epithermal Miocene lavas and breccias Gianella, V.P. (38) 339 Partridge, J.F. Jr. (41) 264 Tucker & Sampson (41)565

CALAVERAS COUNTY

NO.	NAME OF CLAIM	NAME OF OWNER	LOCATION				CLASS BY PROD.	REMARKS AND REFERENCES
			SEC.	T.	R.	B. & M.		
	Garnet Hill	Garnet Hill Tungsten Syndicate	6	7N	16E	MD	D	Scheelite in tactite (G L G)
	White Horse & Bay Horse	Grover C. Bruce C. R. Smith	7	7N	16E	MD	D	Scheelite (G W R)

EL DORADO COUNTY

NO.	NAME OF CLAIM	NAME OF OWNER	LOCATION				CLASS BY PROD.	REMARKS AND REFERENCES
			SEC.	T.	R.	B. & M.		
4	Comeback Consolidated Mine	B.F. Magee Lee Wolf	4	11N	11E	MD	C	Scheelite. Logan, C.A. (38) 365

FRESNO COUNTY

NO.	NAME OF CLAIM	NAME OF OWNER	LOCATION				CLASS BY PROD.	REMARKS AND REFERENCES
			SEC.	T.	R.	B. & M.		
	Occurrences at Twin Lakes		Appr. 29,30	7S	26E	MD	D	Scheelite in skarn Chesterman,C.W. (42)
16	Wes Qualls Defense Group	Wes Qualls	14	9S	26E	MD	C	Scheelite in tactite (J H S) (LB)
	Sadler	Joe Sadler	19	9S	27E	MD	D	Scheelite in tactite (J H S)
	Mud Lakes Group	Tungstore Mines	36 30	9S 9S	26E 27E	MD MD	D	Scheelite in tactite (D M L)
	Sadler	Joe Sadler	19	10S	26E	MD	D	Scheelite in tactite (J H S)
17	Tungstore (Dinkey Creek District)	Tungstore Mines Co	21	10S	26E	MD	C	Scheelite in tactite (D M L)
	We Hope Mine	Ralph E. Carver J. J. Brooks	22	10S	26E	MD	D	Scheelite in tactite (D M L)
	Emerald Peak	John W. Riffe	3	9S	29E	MD	D	Scheelite in tactite Reported by J.W. Riffe

FRESNO COUNTY (CONT.)

NO.	NAME OF CLAIM	NAME OF OWNER	LOCATION				CLASS BY PROD.	REMARKS AND REFERENCES
			SEC.	T.	R.	B. & M.		
	Three Buddies	Louis Kientz Harry Shoeph Fred Kasson	1	11S	23E	MD	D	Scheelite in tactite (J H S)
	Humphreys Prospect	J.W. Humphreys	1	11S	23E	MD	D	Scheelite (W O J)
	Big Oak	J.E. Myers R. Vallandigham	6	11S	23E	MD	D	Scheelite in tactite (W O J)
	Spanish Peak	Al Feuerstein	14,15	11S	24E	MD	D	Scheelite in tactite (W O J) See: MacDonald, G.A.(41)
18	Jack Pot Mine	Bob Barnes Dick George G.S. Peterson A.E. Rathgarn	15	11S	24E	MD	C	Scheelite in tactite (J H S) See: MacDonald, G.A.(41)
19	Reiss	J.A. Reiss	7	11S	25E	MD	C	Scheelite (J H S) See: MacDonald, G.A.(41)
20	Benson Brothers Mine	Benson Bros.	18	11S	25E	MD	C	Scheelite in tactite (J H S) See: MacDonald, G.A.(41)
21	Houghton Brothers Mine	Ernest F. Houghton & Bros.	3,4	12S	26E	MD	C	Scheelite in tactite Tucker and Sampson (41) 566

FRESNO COUNTY (CONT.)

NO.	NAME OF CLAIM	NAME OF OWNER	LOCATION				CLASS BY PROD.	REMARKS AND REFERENCES
			SEC.	T.	R.	B. & M.		
	McBride Tungsten Property		11	12S	26E	MD	D	Scheelite in tactite (J H S)
	Terrill Prospect	Maxson	16,17	12S	25E	MD	D	Scheelite in tactite Bradley, W.W. (15) 470 Laizure, C. McK. (29) 336 Partridge, J.F. Jr. (41) 309 See: MacDonald, G.A. (41)
22	Garnet Dike Mine	Sheridan Bros.	22	12S	27E	MD	C	Scheelite in tactite Tucker & Sampson (41)566
23	Kings River Mine	Kings River Mines	22	12S	27E	MD	C	Scheelite in tactite (D M L)
	Occurrences on South Fork Kings River, Sequoia National Forest		Appr. 6,11	13S	29E	MD	D	Scheelite in tactite (O P J and C W C)
	Dixie Queen	D.O. Whitt	3	14S	26E	MD	D	Scheelite in tactite (W O J)

INYO COUNTY

NO.	NAME OF CLAIM	NAME OF OWNER	LOCATION				CLASS BY PROD.	REMARKS AND REFERENCES
			SEC.	T.	R.	B. & M.		
	Round Valley Peak	D.B. Adamson	3	6S	30E	MD	D	Scheelite in tactite Lemmon, D.M. (41a) 96
24	Adamson Tungsten Deposit	D.B. Adamson	30	6S	30E	MD	C	Scheelite in tactite Tucker & Sampson (38)462 Partridge, J. F. Jr. (41) 292 Lemmon, D.M. (41a) 91
25	Pine Creek Tungsten Mine	U.S. Vanadium Corp	30,31	6S	30E	MD	A	Scheelite in tactite Knopf, A. (18) 124 Tucker, W.B. (21) 301 Hess & Larsen (22) 273 Tucker, W.B. (24) 191 Tucker, W.B. (26) 511 Young, G.J. (26) 605 Tucker & Sampson (38)465 Partridge, J. F. Jr. (41) 295 Tucker & Sampson (41)572 Lemmon, D.M. (41a) 89
26	Round Valley Tungsten (Stevens Group of Claims, or Noble Mine)	El Diablo Mining Company	34	6S	31E	MD	B	Scheelite in tactite Knopf, A. (17) 247 Fink, C. G. (18) 702 Hess, F. L. (21) 938 Hess, F. L. (21a) 977 Tucker, W.B. (21) 302 Tucker, W.B. (26) 512 Hess, F. L. (27) 466 Hess, F. L. (29a) 123 Fink, C. G. (31) 614 Fink, C. G. (33) 527 Fink, C. G. (35) 572 Chapman, R.W. (37) 859 Tucker & Sampson (38)466 Lemmon, D.M. (40a) 512 Partridge, J. F. Jr. (41) 296

INYO COUNTY (CONT.)

NO.	NAME OF CLAIM	NAME OF OWNER	LOCATION				CLASS BY PROD.	REMARKS AND REFERENCES
			SEC.	T.	R.	B. & M.		
27	Western Tungsten Co Mine	Shively, Bircham et al.	34	6S	31E	MD	C	Scheelite in tactite (D M L)
		M. Kinney Looker Austin	8	7S	30E	MD	D	Scheelite (D M L)
	Brownstone Nos. 1 and 2	F.L. Murphree A.L. Covington	8	7S	30E	MD	D	Scheelite in tactite ? (D M L)
	Molly Tungstite Claims	F.L. Murphree A.L. Covington	8	7S	30E	MD	D	Scheelite in tactite (D M L)
27a	Lambert Tungsten Mine	Stanley Lambert	11	7S	30E	MD	C	Scheelite (D M L)
28	Tungstar Mine	Tungstar Corp	15	7S	30E	MD	B	Scheelite in tactite Tucker & Sampson (38)464 Partridge, J. F. Jr. (41) 298 Lenhart, W.B. (41) 67 Lemmon, D.M. (41a) 93
29	Lakeview Tungsten Mine	G. Brown P.W. Carpenter B. Phelps	21	7S	30E	MD	C	Scheelite in tactite Lemmon, D.M. (41a) 95
	J & M Claims	F.R. Lee (lessees)	21,22	7S	30E	MD	D	Scheelite in tactite Lemmon, D.M. (41a) 95

INYO COUNTY (CONT.)

NO.	NAME OF CLAIM	NAME OF OWNER	LOCATION				CLASS BY PROD.	REMARKS AND REFERENCES
			SEC.	T.	R.	B. & M.		
	Sunnyboy Group	R.W. Moore	24	7S	30E	MD	D	Scheelite (D M L)
30	Buttermilk Lease	H.A. Van Loon	9,10	7S	31E	MD	C	Scheelite in tactite Lemmon, D.M. (41a) 100
31	Tungsten Blue Mine	Nick Pappas	12	7S	31E	MD	C	Scheelite in tactite Lemmon, D.M. (40a) 510
32	El Diablo Mining Company (Lucky Strike, Jack Rabbit, Little Sister)	H.O. Johanson	11 12,13	7S	31E	MD	A	Scheelite in tactite Fink, C.G. (17) 725 Knopf, A. (17) 230 Fink, C.G. (18) 702 Waring & Huguenin (19) 133 Hess, F.L. (21) 938 Hess & Larsen (22) 271 Tucker, W.B. (26) 512 Tucker & Sampson (31)304 Lemmon, D.M. (40a) 509 Partridge, J.F. Jr. (41) 294
33	Tungsten City Milling Co (Standard Tungsten Co, Aeroplane Group)	J.V. Baldwin	13	7S	31E	MD	B	Scheelite in tactite Fink, C.G. (17) 725 Knopf, A. (17) 243 Fink, C.G. (18) 701 Waring & Huguenin (19) 119 Hess, F.L. (21) 938 Tucker, W.B. (21) 303 Hess & Larsen (22) 270 Tucker, W.B. (26) 512 Tucker & Sampson (38)464 Tucker & Sampson (40) 27 Lemmon, D.M. (40a) 507 Partridge, J.F. Jr. (41) 299

INYO COUNTY (CONT.)

NO.	NAME OF CLAIM	NAME OF OWNER	LOCATION				CLASS BY PROD.	REMARKS AND REFERENCES
			SEC.	T.	R.	B. & M.		
34	Little McGee Creek	McCloskey Mines Inc	13	7S	31E	MD	C	Scheelite in tactite Tucker & Sampson (41)570
	Boyd and Welch		8	7S	32E	MD	D	Scheelite in tactite Knopf, A. (17) 230 Partridge, J.F. Jr. (41) 293
35	Rossi Mine (Bishop Tungsten Co, Mineral Dome)	Joseph Rossi	25	7S	32E	MD	B	Scheelite in tactite Knopf, A. (17) 248 Tucker & Sampson (38)462 Partridge, J.F. Jr. (41) 292 Lemmon, D.M. (41a) 102
36	Pickup Mine (Chipmunk Deposit)	Tungsten Consol (N.C. Aldo)	33	7S	32E	MD	C	Scheelite in tactite Knopf, A. (17) 247 Partridge, J.F. Jr. (41) 293 Lemmon, D.M. (41a) 100
37	Emergency Group (Deep Springs Valley)	D.F. Shively W.A. Sanger S. Bedell	4	7S	36E	MD	C	Scheelite Quartz vein Tucker, W.B. (21) 301 Tucker, W.B. (26) 511 Tucker & Sampson (38)464 Partridge, J.F. Jr. (41) 310
38	Nicklejohn (White Mountain Scheelite)		5	7S	36E	MD	C	E. Huguenin, field report, 1918

INYO COUNTY (CONT.)

NO.	NAME OF CLAIM	NAME OF OWNER	LOCATION				CLASS BY PROD.	REMARKS AND REFERENCES
			SEC.	T.	R.	B. & M.		
39	Schober & Merrill Groups	Schober (El Diablo Mining Co)	22	8S	31E	MD	C	Scheelite in tactite Reported by El Diablo Mining Co
40	Victory Tungsten	C. Townsend A.H. Lang O. Phillips	27	8S	31E	MD	C	Scheelite in tactite (H G H)
	MacVan Claims	MacVan	2	8S	32E	MD	D	Scheelite in tactite Knopf, A. (17) 246 Partridge, J. F. Jr. (41) 295
	Coyote Valley Prospects (Tungsten Valley Group)	A.H. Peterson John Udder	7,18 19,20	8S	32E	MD	D	Scheelite in tactite Lemmon, D.M. (41a) 103
41	Buckshot		20	8S	33E	MD	C	Scheelite in tactite Knopf, A. (17) 248 Waring & Huguenin (19) 131 Tucker & Sampson (38)467 Partridge, J.F. Jr. (41) 298
	Shannon Creek Mine	A.H. Peterson Robert Kelso (operator)	31	8S	33E	MD	D	Scheelite in tactite (J H S)
42	Scheelite Group	S.G. Drouillard F.L. Over W.H. Leffingwell	19	8S	37E	MD	C	Scheelite in tactite Waring & Huguenin (19) 131 Partridge, J.F. Jr. (41) 297

INYO COUNTY (CONT.)

NO.	NAME OF CLAIM	NAME OF OWNER	LOCATION				CLASS BY PROD.	REMARKS AND REFERENCES
			SEC.	T.	R.	B. & M.		
	Last Rose (Waucoba Tungsten Deposit)	Inyo Metals Co Stuart Bedell Clyde McBride	27	11S	37E	MD	D	Scheelite in tactite Tucker & Sampson (38)467 Partridge, J. F. Jr. (41) 312
43	Division Creek Tungsten Mine	J.L. McCullough L.L. McAfee T.W. Key H.N. Shepard	5	12S	34E	MD	C	Scheelite in tactite Tucker & Sampson (41)568
	Jumbo Mine	G.F. Lund J.W. Thompson	10	13S	36E	MD	D	Scheelite in quartz vein Tucker & Sampson (41)569
44	Shorty Harris Tungsten Mine	Bert Hunter E.G. Mason	7,8	15S	41E	MD	C	Scheelite in tactite Waring & Huguenin (19) 129 Tucker & Sampson (41)574
	Alvord Group	Wm. Elliott Ray Spear Rose Spear	20,21	15S	41E	MD	D	Scheelite in tactite Waring & Huguenin (19) 131 Partridge, J.F. Jr. (41) 310
45	Monarch Tungsten Mine	Monarch Tungsten Co	31	15S	41E	MD	C	Huebnerite Vein in granite Waring & Huguenin (19) 131 Partridge, J.F. Jr. (41) 311

INYO COUNTY (CONT.)

NO.	NAME OF CLAIM	NAME OF OWNER	LOCATION				CLASS BY PROD.	REMARKS AND REFERENCES
			SEC.	T.	R.	B. & M.		
	Lone Pinyon Claims	C.E. Hanbury	27	19S	39E	MD	D	Scheelite in tactite (D M L)
46	Bruce Group	R.W. Wallace	13	19S	40E	MD	C	Scheelite (D M L) See: Kelley, V.C. (38)
	Defiance, Independence, and Thompson Mines	Wagner Assets Realization Corp & American Metals Inc	13 23,25	19S	40E	MD	D	Scheelite Quartz vein Tucker & Sampson (41)567 See: Kelley, V.C. (38)
47	Hayward Mine (St. Charles, Fernando, Durham)	Darwin Cons Tungsten Co	24	19S	40E	MD	B	Scheelite in tactite Tucker, W.B. (26) 484 Tucker & Sampson (38)440 Tucker & Sampson (41)570 See: Kelley, V.C. (38)
	Silver Reef Claims	Mickey Sommers	25	19S	40E	MD	D	Scheelite (D M L) See: Kelley, V.C. (38)
	Beverley Claims	William McKinley McKeever, & Associates	8	20S	40E	MD	D	Scheelite (D M L)
48	Panyo Tungsten Mine	Walter Sorenson	14	20S	40E	MD	C	Scheelite and powellite in tactite Tucker & Sampson (41)571
	Sheep Head Claims (Trail Canyon, 18 miles SW of Furnace Creek Ranch)	Milton L. Knapp		19S	46E	MD	D	Scheelite. Quartz veins in metamorphic limestone (W B T)

INYO COUNTY (CONT.)

NO.	NAME OF CLAIM	NAME OF OWNER	LOCATION				CLASS BY PROD.	REMARKS AND REFERENCES
			SEC.	T.	R.	B. & M.		
49	Mountain Kid Group	Paul Wilbur	19	20S	40E	MD	C	Scheelite in tactite Tucker & Sampson (41)570
50	Keogh Group	J.J. Rogers Wm. G. Tait	23	20S	40E	MD	C	Scheelite in tactite Tucker & Sampson (41)569
51	Stewart-Wonder Mine and other claims	Panamint Mining Co	Appr 11	21S	45E	MD	C	Scheelite Veins in "Marvel dolomitic limestone" (O P J) See: Tucker, W.B. (26) 495 Murphy, F.M. (32) plate IV Sampson, R.J. (32) plate V, page 363
	Feldman Tungsten Mine	Frank Feldman	16	23S	38E	MD	D	Scheelite Quartz vein in granite Tucker & Sampson (38)464 Partridge, J.F. Jr. (41) 311
	Margarita Claim (In Shepherd Canyon)	Eugene Bacoki	Appr 2	22S	42E	MD	D	Reported by Eugene Bacoki
	Copper Queen Mine (6 patented claims)	Jacoby Estate; W.W. Woods D.G. Martin (lessees)	7	6S	37E	MD	D	Scheelite in tactite (D M L)

KERN COUNTY

NO.	NAME OF CLAIM	NAME OF OWNER	LOCATION				CLASS BY PROD.	REMARKS AND REFERENCES
			SEC.	T.	R.	B. & M.		
59	Tungstore Mine No. 2	Tungstore Mines Co	11	25S	29E	MD	C	Scheelite (D M L)
	Cadillac Claim	O.G. Wood	7,8	25S	32E	MD	D	Scheelite in tactite Hess & Larsen (22) 265 Partridge, J.F. Jr. (41) 300
60	King Mine (Sierra Tungsten Group, Herschel Kelso, Owl Mine, Ideal Group Tungsten Claims)	Bill Zellner Brooke Woods J.C. Rook	17,20	25S	32E	MD	C	Scheelite in tactite Hess & Larsen (22) 264 Partridge, J.F. Jr. (41) 302 Tucker & Sampson (41)576
61	Buckhorn Claim (Why Not Claim)	Tom Harper et al	19	25S	32E	MD	C	Scheelite in tactite Hess & Larsen (22) 264 Partridge, J.F. Jr. (41) 305
62	Major Tungsten Mine (Rand Group, Ione and Sweet Mine)	Brooke Woods	19,20	25S	32E	MD	C	Scheelite in tactite Hess & Larsen (22) 263 Partridge, J.F. Jr. (41) 302
	High Power Mine	Patten Peyton Higgins Ellis McCornell	20	25S	32E	MD	D	Scheelite in tactite (D M L)

KERN COUNTY (CONT.)

NO.	NAME OF CLAIM	NAME OF OWNER	LOCATION				CLASS BY PROD.	REMARKS AND REFERENCES
			SEC.	T.	R.	B. & M.		
63	Little Dick Group	C.W. Pascoe	23	25S	33E	MD	C	Scheelite in tactite Tucker & Sampson (40)332 Miller & Webb (40) pl.II Partridge, J.F. Jr. (41) 301
	Mintern Group	C.C. Mintern C.G. Pasley	24	25S	33E	MD	D	Scheelite in tactite Tucker & Sampson (41)576
	Big Blue Group	Kern Mines Inc	28,33	25S	33E	MD	D	Scheelite in gold-bearing veins Prout, J.W. Jr. (40) 411
64	El Diablo – Trojan	El Diablo Mining Co	31	25S	33E	MD	C	Scheelite in tactite Reported by El Diablo Mining Company
	Tungsten Queen Group	Mintern Estate	31	25S	33E	MD	D	Scheelite in tactite Tucker & Sampson (41)579
65	Buck	Robert L. Coughran	6	26S	33E	MD	C	Scheelite in tactite (A W S)
	Syrus Canyon Group	C.W. Pascoe	35	25S	33E	MD	D	Scheelite in tactite Tucker & Sampson (40)333 Miller & Webb (40) pl.II
	Sure Go, Big Shot (1,2), Scheelite King (1,3,4) Starlite	Norman Whitmore Victor Hayck (lessees)	12	25S	36E	MD	D	Scheelite in tactite (W O J and O P J)

KERN COUNTY (CONT.)

NO.	NAME OF CLAIM	NAME OF OWNER	LOCATION				CLASS BY PROD.	REMARKS AND REFERENCES
			SEC.	T.	R.	B. & M.		
	Miranda Group	Theodore Miranda	1	26S	33E	MD	D	Scheelite in tactite Tucker & Sampson (40)332 Miller & Webb (40) pl.II
	Play Boy	Don Hennings	1	26S	33E	MD	D	Scheelite in tactite (A W S)
66	Bald Eagle	Salsouega	31	26S	34E	MD	C	Scheelite in tactite (A W S) See: Miller & Webb (40) pl. II
	Big Lode	Eliza Coughran Mary Canfield	32	26S	34E	MD	D	Scheelite in tactite (D M L)
	Pyavin Group (Indian Wells) (20 claims)	Warner, Merrill, Crowthers (W.J. Petty has contract)	1	26S	37E	MD	D	Scheelite in veins and tactite (W O J and O P J)
	Blue Bird (1-4), Black King (1-7), Hi-Girl (1-3), Hi-Peak (1-2)	Hi-Peak Tungsten Mining Co (Victor J. Hyack)	15	26S	38E	MD	C?	Scheelite in tactite (W O J and O P J)
	Buckeye - Buena Vista (Bald Mountain)		14	27S	32E	MD	D	Scheelite Vein in granite Tucker, W.B. (21) 315 Tucker, W.B. (29) 62
	Howe Group		23	27S	32E	MD	D	Scheelite Vein in granite Tucker, W.B. (21) 315
	Four K Tungsten Mine	H.J. Kutzner	26	273	32E	MD	D	Scheelite Quartz veins Tucker & Sampson (41)575

KERN COUNTY (CONT.)

NO.	NAME OF CLAIM	NAME OF OWNER	LOCATION				CLASS BY PROD.	REMARKS AND REFERENCES
			SEC.	T.	R.	B. & M.		
67	Tungsten King Mine	Zuck Tillman	26	27S	32E	MD	C	Scheelite in quartz vein Tucker, W.B. (21) 315 Tucker, W.B. (26) 62 Tucker & Sampson (40)333 Partridge, J.F. Jr. (41) 303
	Prosperity Tungsten Claim	A.O. Zuck W.R. Tillman	35	27S	32E	MD	D	Scheelite in quartz vein in granite Tucker & Sampson (40)333
	Tungsten Hill Mine	T.M. Smith E.E. Lambert	3	28S	32E	MD	D	Scheelite in tactite Tucker & Sampson (41)579
68	Star Dust and Black Cat	Dorris & Cuddeback (operator)	1	27S	34E	MD	C	Scheelite in tactite (D M L)
	Tungsten Big Lode Group		11,14	27S	34E	MD	D	Scheelite in tactite Tucker & Sampson (41)578
69	Plasse	A.H. Plasse	12	27S	34E	MD	C	Scheelite in tactite (A W S)
	Mountain View Tungsten Mine	George Ramey H. D. Hicks	26	28S	32E	MD	D	Scheelite in tactite Tucker & Sampson (41)577
	Fidgie Group, Nos. 1-6 (in Erskine Canyon)	J.C. Cuddeback H.F. Liebel Wiley C. Dorris	23	27S	33E	MD	D	Scheelite with molybdenite and powellite in tactite (W O J)

KERN COUNTY (CONT.)

NO.	NAME OF CLAIM	NAME OF OWNER	LOCATION				CLASS BY PROD.	REMARKS AND REFERENCES
			SEC.	T.	R.	B. & M.		
70	Little Wonder	J.E. Ramey et al	33	28S	32E	MD	C	Scheelite (A W S)
71	Tungsten Chief Mine (Wall Street Group, Ophir - Zuck)	T.J. McKee T.N. McKee	26 27,33	28S	32E	MD	C	Scheelite in tactite Tucker, W.B. (21) 316 Partridge, J.F. Jr. (41) 304 Tucker & Sampson (41)578
72	Naja Scheelite	H. Butterbred L.V. Stover	1	29S	33E	MD	C	Scheelite in tactite (W B T)
	Williams Ranch Tungsten Deposit	Nick Williams	16	29S	33E	MD	D	Scheelite Granite-schist contact Tucker & Sampson (41)579
	Orrell Group		12	29S	34E	MD	D	Scheelite Vein in granite (W B T)
	Gwynne and Jennette Mine	Otto Geringer Jack Geringer	21,22	29S	34E	MD	D	Scheelite in gold-bearing quartz veins Tucker & Sampson (33)307 Tucker & Sampson (41)575
73	Locarno - Simon Group	N.V. Franceschi	28	29S	34E	MD	C	Scheelite in gold-bearing quartz veins Tucker & Sampson (41)576

KERN COUNTY (CONT.)

NO.	NAME OF CLAIM	NAME OF OWNER	LOCATION				CLASS BY PROD.	REMARKS AND REFERENCES
			SEC.	T.	R.	B. & M.		
	Top of the World	H.G. Hubbard et al	34	30S	32E	MD	D	Contact, granodiorite and schist (H G H)
74	Blue Point Deposit	Frank Feldman	10,11 14,15	30S	36E	MD	C	Scheelite and wolframite in greisenized granite Partridge, J. F. Jr. (41) 312
75	Consolidated Mines		35	29S	40E	MD	C	Scheelite Vein in schist Fink, C.G. (16) 688 Hulin, C.D. (25) 132 Fink, C.G. (26) 702
76	Gold Wash Claim (Ben Hur Claim)	Ed Herkelrath	1	30S	40E	MD	C	Scheelite Vein in granite Hulin, C.D. (25) 129 Tucker & Sampson (31)342
	Monarch Rand Mine	Lacy Manufacturing Co (lessee)	1,12	30S	40E	MD	D	Scheelite Placer deposit Brown, G.C. (16)505,507 Tucker & Sampson (41)577
77	Yellow Aster Mine	Yellow Aster Mining & Milling Co	2	30S	40E	MD	C	Scheelite in quartz veins Brown, C.G. (16) 514 Hulin, C.D. (25) 121 Partridge, J. F. Jr. (41) 291
	Big Tungsten	J. Kreta	3	30S	40E	MD	D	Scheelite in quartz veins (J H S)

KERN COUNTY (CONT.)

NO.	NAME OF CLAIM	NAME OF OWNER	LOCATION				CLASS BY PROD.	REMARKS AND REFERENCES
			SEC.	T.	R.	B. & M.		
78	Sunset Group (Hawk Mine)	M.J. Lovett W.M. Price	6	30S	40E	MD	C	Scheelite in limestone and schist Tucker, W.B. (21) 316 Partridge, J.F. Jr. (41) 313
79	Royal Bohee Group (Royal Bohn Group)	A.M. Powell	9	30S	40E	MD	C	Scheelite Veins in schist Tucker, W.B. (21) 316 Partridge, J.F. Jr. (41) 289
80	Stanford Group (Capitola, Gold Crown Cons, Santa Ana Gold, Sunshine, Winnie)	Santa Ana Gold Mines Co	1 11,12	30S	40E	MD	C	Scheelite in gold-bearing quartz veins Brown, G.C. (16) 494, 509, 510, 513 Tucker, W.B. (29) 47 Partridge, J.F. Jr. (41) 286, 287, 290, 291
	Radcliffe Mine		12	30S	40E	MD	D	Scheelite Vein in schist Tucker, W.B. (21) 316 Tucker, W.B. (29) 63
81	Minnehaha		6	31S	34E	MD	C	Scheelite Vein in schist Hulin, C.D. (25) 137 Tucker & Sampson (33)319

KERN COUNTY (CONT.)

NO.	NAME OF CLAIM	NAME OF OWNER	LOCATION				CLASS BY PROD.	REMARKS AND REFERENCES
			SEC.	T.	R.	B. & M.		
	Pine Tree Mine	Sholine Clausenius	4	11N	15W	SB	D	Scheelite Vein in granite Tucker & Sampson (41)577
82	Summit Lime Company	Summit Lime Co	35	11N	15W	SB	C	Scheelite Vein in granite Tucker & Sampson (41)578
	General MacArthur Group	L.M. Allen	2	10N	15W	SB	D	Scheelite Tucker & Sampson (41)575

MADERA COUNTY

NO.	NAME OF CLAIM	NAME OF OWNER	LOCATION				CLASS BY PROD.	REMARKS AND REFERENCES
			SEC.	T.	R.	B. & M.		
	Thousand Islands Lake, southwest side		Appr 35	2S	25E	MD	D	Scheelite in tactite (O P J and C W C)
	North of Nidiver Cabin on Shadow Creek		Appr 1	3S	25E	MD	D	Scheelite in tactite (OPJ and CWC) See: Erwin, H.D. (34)
10	Beasore Group	Minaret Cons Mines Co	36	3S	25E	MD	C	Huebnerite Vein in pegmatite Bradley, W.W. (26) 545 Erwin, H.D. (34) 77 Partridge, J.F. Jr. (41) 313
	Ghost Canyon Group and Duckpond	John H. Walker	36 1	4S 5S	23E 23E	MD	D	Scheelite in tactite (J M L) (D M L)
	Church and Jones	Denver Church Thos. Jones	1	5S	23E	MD	D	(D M L)
	Walker Group (10 claims on Chiquita Creek, north of Bass Lake)	Walker Tungsten Mines, Inc	7	5S	24E	MD	D	Scheelite in tactite Tucker & Sampson (41)580
	Yellowjacket Prospect	Dan Topping Louis Luchetti	3,4 10	5S	23E	MD	D	Scheelite (W O J)
	Bull of the Woods Nos. 1,2,3	Jess Ward	24	4S	24E	MD	D	Scheelite in tactite (W O J)

MADERA COUNTY (CONT.)

NO.	NAME OF CLAIM	NAME OF OWNER	LOCATION				CLASS BY PROD.	REMARKS AND REFERENCES
			SEC.	T.	R.	B. & M.		
	Jimmie	Jess Ward	36	4S	24E	MD	D	Scheelite in tactite (W O J)
11	Jones Mine	Thomas Jones	36	4S	24E	MD	D	Scheelite in tactite Tucker & Sampson (41)580
	Punjab	Lawrence Cobb	36	4S	24E	MD	D	Scheelite in tactite (W O J)
		Weatherby	31	4S	25E	MD	D	Scheelite in tactite (W O J)
11	Strawberry Mine (Haggerty & Madden Mine, Cobb Mine) (Jackass District)	Northumberland Mining Co	1 6 25,36	5S 5S 4S	24E 25E 24E	MD	C	Scheelite in tactite Tucker & Sampson (41)580
	Red Lily	Hughes Brothers Sherwood Greene	5	6S	22E	MD	D	Scheelite in tactite (D M L)
	Fleming	California Institute of Technology	7	6S	22E	MD	D	Scheelite in tactite (R H E)
	Tin Bucket (near Sugar Pine)	J.R. Hossack Mrs. J.R. Hossack J.D. Pell	7	6S	22E	MD	D	Scheelite in tactite Tucker & Sampson (41)580
	Victory Nos. 1 and 2	California Institute of Technology	20	6S	22E	MD	D	Scheelite in tactite (H G H)

MADERA COUNTY (CONT.)

NO.	NAME OF CLAIM	NAME OF OWNER	LOCATION				CLASS BY PROD.	REMARKS AND REFERENCES
			SEC.	T.	R.	B. & M.		
	Tip Top Mining Company (Sellers Mine)	Claude Sellers	23	6S	22E	MD	D	Scheelite in tactite (J H S)
	Love and Ibbettson	J. Love J. Ibbettson	13	7S	22E	MD	D	Scheelite in tactite (J H S) (D M L)
	Silver Horde Mine	B. Manners	28,29	6S	23E	MD	D	Wolframite reported in 1922 Laizure, C.McK. (22) 305 Partridge, J.F. Jr. (41) 314
12	I.X.L. Mine (12 miles north of Raymond)		12	7S	19E	MD	C	Wolframite in quartz vein in andalusite mica schist Hess, F.L. (08) 271 Bradley & McLaughlin (15) 568 Laizure, C.McK. (28)344 Partridge, J.F. Jr. (41) 314
13	R. & W. Tungsten Company	T. Jones	24,25 30	7S 7S	20E 21E	MD MD	C	Scheelite in tactite (D M L)
	R. & W. Mining Company	Rapp & Co	18	7S	21E	MD	D	Scheelite in tactite (J H S)
		Denver Church	21	8S	22E	MD	D	(J H S)

MADERA COUNTY (CONT.)

NO.	NAME OF CLAIM	NAME OF OWNER	LOCATION				CLASS BY PROD.	REMARKS AND REFERENCES
			SEC.	T.	R.	B. & M.		
	Ellis	Chas. Ellis	29	8S	22E	MD	D	Scheelite in tactite (J H S)
	Welsh Ranch Deposit	Anglo-American Co	32,33 3,4, 10	8S 9S	22E 22E	MD MD	D	Scheelite in tactite Little, J.M. (42a)
	Sherwood Green Mine	Otis Teaford	10,14	9S	22E	MD	D	Scheelite in tactite (J H S)
	Lone Pine No. 3	J.B. Hoskins	15	9S	22E	MD	D	Scheelite in tactite (D M L)
14	Wissman Brothers	Clayton Wissman W.W. Knowles	4	8S	24E	MD	C	Scheelite in tactite (J H S)
15	Hogue Ranch Mine	Root & Carruthers	9	8S	24E	MD	C	Scheelite in tactite (J H S)
	Washington	Roscoe Patterson Fred Golding (leaser)	21 28	6S	20E	MD	D	Scheelite in tactite (W O J) (D M L)
	Hughes Claim	Hoskins DeMasters	3	9S	23E	MD	D	Scheelite in tactite (D M L)

MARIPOSA COUNTY

NO.	NAME OF CLAIM	NAME OF OWNER	LOCATION				CLASS BY PROD.	REMARKS AND REFERENCES
			SEC.	T.	R.	B. & M.		
	Big Grizzly Group (Hite Cove Mining District)	J.H. Metzler	17	3S	19E	MD	D	Scheelite Quartz vein in granite Tucker & Sampson (41)580
	Victory Tungsten Mines (3 claims)	A.C. Harding C.P. Gann	8	3S	20E	MD	D	Scheelite in tactite (A W S)
	War Baby	Lester Bissett J.E. Rea	9	6S	21E	MD	D	Scheelite in tactite (W O J) (D M L)

MONO COUNTY

NO.	NAME OF CLAIM	NAME OF OWNER	LOCATION				CLASS BY PROD.	REMARKS AND REFERENCES
			SEC.	T.	R.	B. & M.		
5	Dickson Brothers Claim (White Goat Claims; Topaz Lake Mine)	H.A. Dickson Mabel Jones Ed Dickson (Nevada-Massachusetts Co; Rare Metals Corp)	Appr 35	9N	23E	MD	C	Scheelite in tactite (D M L and A W S)
	McKay	A.F. McKay	34	9N	23E	MD	D	Scheelite in tactite Reported by A.F. McKay
	Brown Horse (Colville)	W.M. Tennant	23	8N	22E	MD	D	Scheelite in tactite Reported by W. M. Tennant
	Golden Gate		26	8N	22E	MD	D	Scheelite Quartz vein in schist Sampson & Tucker (40)124
	Laughmont Claims Fortuna	Laughlin Montrose Sturgeon et al.	10	7N	23E	MD	D	(D M L) (L B)
	Mono Tungsten Group (North of Tioga Pass)	Gus Hess C.A. Crane	6	2N	25E	MD	D	Scheelite in tactite (O P J and C W C)
	West Tower Claims	J.W. Otey	3	3S	31E	MD	D	Scheelite in tactite Partridge, J.F. Jr. (41) 592 Lemmon, D.M. (41) 300

MONO COUNTY (CONT.)

NO.	NAME OF CLAIM	NAME OF OWNER	LOCATION				CLASS BY PROD.	REMARKS AND REFERENCES
			SEC.	T.	R.	B. & M.		
6	Black Rock Tungsten Mine	Tungsten Corp of California	14,23	3S	31E	MD	B	Scheelite in tactite Hess & Larsen (22) 276 Sampson & Tucker (40)147 Lemmon, D.M. (41) 587 Partridge, J.F. Jr. (41) 314
	Ameil Group	Sam Morris	23	3S	31E	MD	D	Powellite in tactite Sampson & Tucker (40)147 Lemmon, D.M. (41) 591 Partridge, J.F. Jr. (41) 295
7	Goos Mine	J.A. Coos Estate	26	3S	31E	MD	C	Scheelite in tactite Lemmon, D.M. (41) 591
	Horseshoe No. 1 (south of Mammoth P.O.)	Henry F. Seliger Sr. Henry F. Seliger Jr.	11	4S	27E	MD	D	Tactite (OPJ and CWC)
	Laurel Canyon Deposits	W.E. Selbie Lloyd Summers Lee Moyle Estate	Appr 20,21	4S	28E	MD	D	Scheelite in tactite Mayo, E.B. (34) 83
	Tungsten Group of Claims Nos. 1, 2, 3, 4							
	Bloody Mountain Deposits		29,32					Scheelite with molybdenite
	Tiptop Claims	M. Harlan C. Thorington R.W. Phelps	19	4S	29E	MD	D	Scheelite in tactite Lemmon, D.M. (41a) 99
8	Hilton Creek Mine	R.W. Phelps Dan Nichol	11	5S	29E	MD	C	Scheelite in tactite Lemmon, D.M. (41a) 97 Mayo, E.B. (34) 84
9	Scheelore Tungsten Mine	H.A. Van Loon J.E. Morhart	30	5S	29E	MD	C	Scheelite in tactite Tucker & Sampson (41)581

NEVADA COUNTY

NO.	NAME OF CLAIM	NAME OF OWNER	LOCATION				CLASS BY PROD.	REMARKS AND REFERENCES
			SEC.	T.	R.	B. & M.		
	Pioneer Mine	Idaho-Maryland Mines Corp	24	16N	8E	MD	D	Scheelite Vein in granite Logan, C.A. (30) 127 Logan, C.A. (41) 443
1	Empire Mine	Newmont Mining Co	35	16N	8E	MD	C	Scheelite Vein in granite MacBoyle, E. (18) 29 Johnston, W.D. Jr. (40) 43 Logan, C.A. (41) 443 Partridge, J.F. Jr. (41) 315
	Howard Hill Mine (Lucky Mine, Cambridge Mine)	Idaho-Maryland Mines Corp	36	16N	8E	MD	D	Scheelite Vein in porphyry Hanks, H.G. (84) 353 Lindgren, W. (96) 115
2	Union Hill Mine	Idaho-Maryland Mines Corp	25,36	16N	8E	MD	C	Scheelite Schistose porphyritic breccia McDonald, P.B. (16) 40 Fink, C.G. (16) 688 MacBoyle, E. (18) 29,263 Hess, F.L. (21) 938 Johnston, W.D. Jr. (40) 43 Partridge, J.F. Jr. (41) 315 Logan, C.A. (41) 443 Farmin, R. (41) 224

NEVADA COUNTY (CONT.)

NO.	NAME OF CLAIM	NAME OF OWNER	LOCATION				CLASS BY PROD.	REMARKS AND REFERENCES
			SEC.	T.	R.	B. & M.		
3	Lava Cap Mine	Lava Cap Mining Corp	28	16N	9E	MD	C	Scheelite Quartz vein in slate Logan, C.A. (41) 443
	Bullion Mine	Idaho-Maryland Mines Corp	1,2	15N	8E	MD	D	Scheelite Quartz vein in granite (E D)
	Amador Consolidated	D. Johnson	11	15N	8E	MD	D	Scheelite Quartz vein in granite Johnston, W.D. Jr. (40) 43 Logan, C.A. (41) 443

PLUMAS COUNTY

NO.	NAME OF CLAIM	NAME OF OWNER	LOCATION				CLASS BY PROD.	REMARKS AND REFERENCES
			SEC.	T.	R.	B. & M.		
	Grizzly Tungsten No. 1	C.B. Goodrich	11	23N	5E	MD	D	Scheelite in schist Tucker & Sampson (41)581

RIVERSIDE COUNTY

NO.	NAME OF CLAIM	NAME OF OWNER	LOCATION				CLASS BY PROD.	REMARKS AND REFERENCES
			SEC.	T.	R.	B. & M.		
	Beatty Claims	Frank Beatty et al	32 33,34	4S	4W	SB	D	Scheelite Quartz veins in gneiss E. Huguenin, field report, 1918
	Alice Group	Reliance Cons Mines Co	25,36	1S	23E	SB	D	Gold vein on contact of schist with granite Merrill, F.J.H. (19) 544 Tucker & Sampson (29)472 Tucker, W.B. (34) 320
110	Blue Boy and Black Mountain Group	J.O. Mayall	3	4S	1E	SB	C	Scheelite in tactite Tucker & Sampson (41)582
	Murray Canyon	Andreas Canyon Club	9	5S	4E	SB	D	(D M L)
	Magnesium Canyon Tungsten Mine (Cottonwood Claims)	Mr. & Mrs. Milton L. Knapp	22	5S	5E	SB	D	Scheelite in tactite Tucker & Sampson (41)582
111	Garnet Queen Tungsten Mine	Jack Pyster Ogden Mayall	20	7S	5E	SB	C	Scheelite Quartz vein in schist and granite Tucker & Sampson (41)582

RIVERSIDE COUNTY (CONT.)

NO.	NAME OF CLAIM	NAME OF OWNER	LOCATION				CLASS BY PROD.	REMARKS AND REFERENCES
			SEC.	T.	R.	B. & M.		
	Milkyway Claims	Thackery Harris Puyster Howell	26,27	7S	5E	SB	D	(D M L)
112	Pawnee Mine (Carr Mine)	Emerson L. Carr William Carr	31	8S	3E	SB	C	Scheelite in tactite Tucker & Sampson (40) 48 Tucker & Sampson (41)582
	Miller Ranch Deposit	J.C. Miller	2	8S	6E	SB	D	Scheelite in tactite Tucker & Sampson (41)583

SAN BERNARDINO COUNTY

NO.	NAME OF CLAIM	NAME OF OWNER	LOCATION				CLASS BY PROD.	REMARKS AND REFERENCES
			SEC.	T.	R.	B. & M.		
83	Black Hawk Mine (Leonard & Halloran)		7	30S	41E	MD	C	Scheelite Vein in schist Brown, G.C. (16) 489 Cloudman, Merrill, & Huguenin (19) 837 Tucker, W.B. (21) 372 Hulin, C.D. (25) 130 Tucker & Sampson (31)294 Lemmon & Dorr (40) 243 Partridge, J.F. Jr. (41) 285
84	Jersey Lily Group	Rare Metals Refining Co	7	30S	41E	MD	C	Scheelite Partridge, J. F. Jr. (41) 288
	Gold Basin Mine	Clarence Barker	7	30S	41E	MD	D	Scheelite in quartz veins (J H S)
85	Quirk Claims	Quirk	17	30S	41E	MD	C	Massive scheelite in quartz vein Cloudman, Merrill, & Huguenin (19) 839 Partridge, J. F. Jr. (41) 289
86	Buckeye Tungsten Mine	Buckeye Tungsten Co	18	30S	41E	MD	C	Scheelite Vein in granite Tucker, W.B. (21) 373 Partridge, J.F. Jr. (41) 286
87	Redondo Pete Mine	Atolia-Rand Placers	19	30S	41E	MD	C	Scheelite Placer deposit Tucker & Sampson (31)294 Lemmon & Dorr (40)242 Partridge, J. F. Jr. (41) 285

SAN BERNARDINO COUNTY (CONT.)

NO.	NAME OF CLAIM	NAME OF OWNER	LOCATION				CLASS BY PROD.	REMARKS AND REFERENCES
			SEC.	T.	R.	B. & M.		
88	Top Notch Claim	American Gold & Tungsten Corp	19	30S	41E	MD	C	Scheelite Vein in granite Lemmon & Dorr (40) 244 Partridge, J. F. Jr. (41) 284
89	Acaley, Amity, Attila, Churchill, Flat Iron, Goldstone, Mahood, Par, Papoose, Potato Patch, Rainstorm, Spanish, Paradox 1 & 3, and Union Mines	Atolia Mining Co	19,20	30S	41E	MD	A	Scheelite Vein in granite Fink, C.G. (15) 747 Hess, F. L. (16) 790 Fink, C.G. (16) 687 Fink, C.G. (17) 724 Hess, F.L. (17a) 824 Fink, C.G. (18) 700 Hess, F.L. (19) 791 Cloudman, Merrill, & Huguenin (19) 830 Tucker, W.B. (21) 370 Hess, F.L. (21) 939 Hess, F.L. (21a) 979 Fink, C.G. (24) 684 Hulin, C.D. (25) 70, 125 Fink, C.G. (26) 701 Fink, C.G. (28) 593 Fink, C.G. (29) 609 Hess, F.L. (29) 261 Hess, F.L. (29a) 123 Fink, C.G. (31) 614 Tucker & Sampson (31) 365 Fink, C.G. (32) 557 Hess, F.L. (33) 182 Fink, C.G. (34) 572 Fink, C.G. (35) 572 Hess, F.L. (35) 494 Fink, C.G. (36) 587 Fink, C.G. (37) 601 Lemmon & Dorr (40) 230 Partridge, J. F. Jr. (41) 284

SAN BERNARDINO COUNTY (CONT.)

NO.	NAME OF CLAIM	NAME OF OWNER	LOCATION				CLASS BY PROD.	REMARKS AND REFERENCES
			SEC.	T.	R.	B. & M.		
90	Rose Fraction (Atolia)		20	30S	41E	MD	C	Scheelite Placer deposit Cloudman, Merrill, & Huguenin (19) 839
91	Gypsy Group	A. Nixon	20	30S	41E	MD	C	Scheelite Fink, C.G. (18) 701 Partridge, J. F. Jr. (41) 287
92	Osdick Group	P.J. Osdick	20,21	30S	41E	MD	C	Scheelite Vein in granite Fink, C.G. (16) 687 Martin, A.H. (16) 291 Hess, F.L. (17a) 824 Cloudman, Merrill, & Huguenin (19) 837 Lemmon & Dorr (40) 241 Partridge, J. F. Jr. (41) 288
93	Treasury Group	D.V. McBride M.H. Elliott C.W. Peterson	21	30S	41E	MD	C	Scheelite Placer deposit Cloudman, Merrill, & Huguenin (19) 839 Partridge, J.F. Jr. (41) 291
94	Scheelite Group	Hart	21	30S	41E	MD	C	Scheelite Placer deposit Martin, A.H. (16) 687 Cloudman, Merrill, & Huguenin (19) 839 Partridge, J.F. Jr. (41) 290

SAN BERNARDINO COUNTY (CONT.)

NO.	NAME OF CLAIM	NAME OF OWNER	LOCATION				CLASS BY PROD.	REMARKS AND REFERENCES
			SEC.	T.	R.	B. & M.		
95	Atolia-Rand Placers Inc (Nieto Placer Group)	Atolia-Rand Placers Inc	19,30	30S	41E	MD	C	Scheelite Placer deposit Tucker & Sampson (31)294 Laizure, C.McK. (34) 246 Fink, C.G. (35) 572 Fink, C.G. (37) 601 Lemmon & Dorr (40) 242 Partridge, J. F. Jr. (41) 285
	Spud Patch Placer	Hoefling Bros.	19,30	30S	41E	MD	D	
96	Black Hawk Tungsten Mines	Black Hawk Tungsten Mines Corp	19,20 29,30	30S	41E	MD	C	Scheelite in quartz veins Tucker & Sampson (30)293 Tucker & Sampson (31)366 Partridge, J. F. Jr. (41) 286
97	Federal Company's Group (Gustave, Toboggan)	J.C. Raynor N.H. Meyers G.T. Ingram	19,20	30S	41E	MD	C	Scheelite Placer deposit Fink, C.G. (16) 687 Cloudman, Merrill, & Huguenin (19) 837, 839 Lemmon & Dorr (40) 240 Partridge, J. F. Jr. (41) 286, 288
98	Mojave Tungsten Mine	Colosseum Gold Mines Corp	15	17N	13E	SB	C	Wolframite, huebnerite, in quartz vein in granite Fink, C.G. (17) 724 Cloudman, Merrill, & Huguenin (19) 839 Partridge, J. F. Jr. (41) 307

SAN BERNARDINO COUNTY (CONT.)

NO.	NAME OF CLAIM	NAME OF OWNER	LOCATION				CLASS BY PROD.	REMARKS AND REFERENCES
			SEC.	T.	R.	B. & M.		
99	Bernice Group and Maynard Tin Mine	W.W. Hartman (lessee)	25	15N	13E	SB	C	Scheelite in tactite (D M L)
	Silver Star Group	Chas. E. Richards C.E. Hammett	6, 7	15N	14E	SB	D	Scheelite in tactite Tucker & Sampson (41)585
100	Standard No. 1 (Blue Grass Claims)	Riley Bembry	18	15N	14E	SB	C	Scheelite in tactite Tucker & Sampson (41)586
101	Carbonate Group	J.R. Crawford Matt McCarthy George Carruthers	23	14N	15E	SB	C	Wolframite Quartz veins in pegmatite Fink, C.G. (16) 688 Cloudman, Merrill, & Huguenin (19) 841 Tucker, W.B. (21) 373 Partridge, J.F. Jr. (41) 306
	(Shafer, Schloerb, and Field Mine)	R.H. Shafer E.W. Schloerb W.L. Field						
	(Mojave Annex Mine)	Mojave Annex Tungsten Co						
	Tungsten King Group	J.F. Brooke F.M. Brooke F.W. Chausse J.G. Bliss	32	14N	15E	SB	D	Huebnerite and wolframite in pegmatite Cloudman, Merrill, & Huguenin (19) 842 Partridge, J.F. Jr. (41) 308
	Brooke Molybdenite and Tungsten Mine	J.F. Brooke M.F. Brooke	35	14N	15E	SB	D	Wolframite, huebnerite, and molybdenite in pegmatite Tucker & Sampson (41)584

SAN BERNARDINO COUNTY (CONT.)

NO.	NAME OF CLAIM	NAME OF OWNER	LOCATION				CLASS BY PROD.	REMARKS AND REFERENCES
			SEC.	T.	R.	B. & M.		
102	Dorr Tungsten Mine	Elliott-Potter Mining & Milling Co	36	14N	15E	SB	C	Huebnerite in quartz vein Tucker & Sampson (41)584
	Gillsmith and Victory Group	H.S. Gillies	17	14N	16E	SB	D	Scheelite in taotite Tucker & Sampson (41)585
103	Sagamore Mine	Francis Cage & Associates	20	14N	16E	SB	C	Huebnerite in quartz veins with galena, sphalerite, stibnite, chalcopyrite, and silver Cloudman, Merrill, & Huguenin (19) 790 Partridge, J.F. Jr. (41) 308
	Live Oak Mine	W.F. Lineberger H.S. Chase (lessees)	29	14N	16E	SB	D	Scheelite and sphalerite in quartz vein (D M L)
	Paradise Mountains Tungsten Deposit	P.R. Hetherington	6,7	12N	2E	SB	D	Scheelite in taotite Tucker & Sampson (41)585
104	Pat Group	J.W. Strawn Thompson	1	11N	14E	SB	C	Wolframite Vein in granite Reported by W.F. Lineberger

SAN BERNARDINO COUNTY (CONT.)

NO.	NAME OF CLAIM	NAME OF OWNER	LOCATION				CLASS BY PROD.	REMARKS AND REFERENCES
			SEC.	T.	R.	B. & M.		
	Francis Copper Mine		4,5	11N	14E	SB	D	Tungsten with copper in porphyry granite Tucker, W.B. (21) 341 Tucker & Sampson (30)210 Tucker & Sampson
105	Confidence Copper Mine	Edward Blewett	5	11N	14E	SB	C	Wolframite Quartz veinlets in pegmatite Tucker, W.B. (21) 340 Tucker & Sampson (31)269
106	Lombard and Main Group (Louisiana-California Co) (Vanadium Gold Co)	A.L. Lombard, J.F. Main Estate	20	11N	17E	SB	C	Wolframite Veins in granite Cloudman, Merrill, & Huguenin (19) 845, 849 Newman, M.A. (22) 310
107	Shadow Mountain Mines (North Tungsten Fields)	Shadow Mountain Tungsten Inc Just Associates	30,31	8N	6W	SB	C	Scheelite in tactite Tucker & Sampson (40) 78 Partridge, J.F. Jr. (41) 316
	El Mirage Mine	Mines Dev Co	32	7N	6W	SB	D	Scheelite in tactite (J H S)
	Bonanza Dome and Beacon Group	Nicholas Baxter Norris Williams	32	8N	6W	SB	D	Scheelite in tactite Tucker & Sampson (40) 59
	Keystone		18	7N	2W	SB	D	Ferberite (?) Tertiary volcanics (R H E)
108	New Discovery Mine	Nicholas Baxter Oliver Adams	6	6N	6W	SB	C	Scheelite in tactite Tucker & Sampson (40) 71

SAN BERNARDINO COUNTY (CONT.)

NO.	NAME OF CLAIM	NAME OF OWNER	LOCATION				CLASS BY PROD.	REMARKS AND REFERENCES
			SEC.	T.	R.	B. & M.		
	Four Brothers Mine	Joseph Scheerer	3	6N	4W	SB	D	Scheelite Vein in granite Cloudman, Merrill, & Huguenin (19) 815 Partridge, J.F. Jr. (41) 316
	Star Dust Group	W.W. Woods	12	5N	1W	SB	D	Tucker & Sampson (41)586
	Victory Tungsten Group	L.J. Rouchleau Maude M. Richardson	6	5N	17E	SB	D	Scheelite Veins in granite (W B T)
	Blue Vase Group	William Baur	2	2N	3E	SB	D	Scheelite Quartz veins Tucker & Sampson (41)584
	Sunnyside Mine (Livingston and Morongo King)	G.M. Bussey E.F. Bain	27	2N	3E	SB	D	Scheelite in gold quartz vein; also in taotite Cloudman, Merrill, & Huguenin (19) 800 Tucker & Sampson (41)586
109	United Tungsten Copper Mines	United Tungsten Copper Mine Corp	32 5	2N 1N	3E 3E	SB	C	Scheelite in taotite Tucker, W.B. (21) 374 Hess & Larsen (22) 261 Partridge, J.F. Jr. (41) 317

SAN DIEGO COUNTY

NO.	NAME OF CLAIM	NAME OF OWNER	LOCATION				CLASS BY PROD.	REMARKS AND REFERENCES
			SEC.	T.	R.	B. & M.		
113	Oak Grove Tungsten Mine (Aguanga Mountains)	Bert Simmons J. Wentworth	16	9S	2E	SB	C	Scheelite in tactite Hess & Larsen (22) 260 Tucker, W.B. (25) 353 Partridge, J.F. Jr. (41) 318
	Beauty Mountain Tungsten Mines	Marie B. Teuscher	1	9S	3E	SB	D	Scheelite Tucker & Reed (39) 32
114	Easy Group	Lloyd Mitchell et al	5	9S	3E	SB	C	Scheelite Tucker & Reed (39) 32
115	Gold Standard Group (Deer Park District)		12	15S	4E	SB	C	Scheelite in gold-quartz veins Tucker, W.B. (25) 353 Partridge, J.F. Jr. (41) 317
116	Sundown Mine	B. J. Chamberlain Eugene Rice	28	15S	4E	SB	C	Scheelite in tactite Tucker & Sampson (41)587

SHASTA COUNTY

NO.	NAME OF CLAIM	NAME OF OWNER	LOCATION				CLASS BY PROD.	REMARKS AND REFERENCES
			SEC.	T.	R.	B. & M.		
	Washington Mine (at French Gulch)	J.H. Scott Co & Durand A. Hall	16	33N	7W	MD	D	Scheelite in the "Dean" vein Averill, C.V. (39) 156 Tuoker & Sampson (41)587

TRINITY COUNTY

NO.	NAME OF CLAIM	NAME OF OWNER	LOCATION				CLASS BY PROD.	REMARKS AND REFERENCES
			SEC.	T.	R.	B. & M.		
	Clerbus Mae Mine	B. Berry Roby	29	9N	8E	H	D	Scheelite Quartz vein in granitic rock Reported by Burtt L. Berry
		Chas. Heath Don Matheson Frank McCoy	Appr 10	35N	9W	MD	D	Scheelite in tactite Reported by L.T. Allen

TULARE COUNTY

NO.	NAME OF CLAIM	NAME OF OWNER	LOCATION				CLASS BY PROD.	REMARKS AND REFERENCES
			SEC.	T.	R.	B. & M.		
52	Harrel Hill Mine	C.A. Parlier et al	11	15S	26E	MD	C	Scheelite in tactite Tucker & Sampson (41)566
	In Aukland District	J.A. Barrington	21	15S	27E	MD	D	Reported by J.A.B.
	Homer Ranch	Homer Estate	34 19,20	16S 16S	27E 28E	MD MD	D	Scheelite in tactite (O P J) See: Durrell, C. (40)
	Occurrence on highway, Sequoia National Park; Middle Fork Kaweah River		Appr 13	16S	29E	MD	D	Scheelite in tactite (O P J and C W C)
	Occurrence, near Empire Mine		Appr 11	17S	31E	MD	D	Scheelite in tactite (O P J and C W C) See: Franke, H.A. (30) Knopf & Thelen (05)
	Occurrence at Cherokee, opposite Forest Guard Station		Appr 16	17S	31E	MD	D	Scheelite in tactite (O P J and C W C)
53	Three Rivers Mine	H.E. Root	16	18S	29E	MD	C	Scheelite in tactite (W O J)
	Big Jim	Will Gill	11	18S	29E	MD	D	Scheelite in tactite (L B)
	Royal Tungsten Group	Geo. W. Hicks & Son	26	18S	29E	MD	D	Scheelite in tactite (W O J)
	Tulare County Tungsten Mines	Will Gill Ranch D.F. Lauricella (Pres.)	14	19S	28E	MD	C	Scheelite in tactite (D M L)

TULARE COUNTY (CONT.)

NO.	NAME OF CLAIM	NAME OF OWNER	LOCATION				CLASS BY PROD.	REMARKS AND REFERENCES
			SEC.	T.	R.	B. & M.		
	Yokohl Valley	Will Gill	11	19S	27E	MD	D	Scheelite in tactite (D M L) See: Durrell, C. (40)
	Gill Ranch Mine	Vernon Gill	12,13	21S	29E	MD	D	Scheelite in tactite (D M L)
	Tule Indian Reservation	Mike Redelez	7	22S	30E	MD	D	Scheelite in tactite (W O J)
	Location: Brush Creek near Fairview	Samuel T. Halsted S.D. Crotsenberg	36	22S	32E	MD	D	Scheelite in tactite Reported to (W O J)
54	Western Exploration Co		35	23S	30E	MD	C	Scheelite in tactite (W O J)
	Billy Boy, Bear Paw, Buckeye, Gray Fox, Gun Barrel, Pinto Ledge, Silver King, Lost Dutchman, Top Grade, Lone Pine, Tanny May, Busy Bee	L.M. Rhoads B.C. Rhoads B.F. Rhoads W.A. Whitley S. Hooker F.E. Stone	26,27 34,35	23S	31E	MD	D	Scheelite in tactite (L B)
55	Verne Tyler Mine	Verne Tyler	33,34	23S	31E	MD	C	Scheelite in tactite (D M L) Partridge, J.F. Jr. (41) 319
56	Indian Mine	H. Frames	35	24S	29E	MD	C	Scheelite in tactite (W O J)
57	Wible Mine	Tungstore Mines Co	31	24S	31E	MD	C	Scheelite (D M L)
58	Tungstore Mine (Kennedy, Jack Ranch)	Tungstore Mines Co	32	24S	31E	MD	B	Scheelite in tactite Franke, H.A. (30) 464 Partridge, J.F. Jr. (41) 318
	Anita May Claim		36	24S	31E	MD	D	Scheelite in tactite Franke, H.A. (30) 465 Partridge, J.F. Jr. (41) 318

TUOLUMNE COUNTY

NO.	NAME OF CLAIM	NAME OF OWNER	LOCATION				CLASS BY PROD.	REMARKS AND REFERENCES
			SEC.	T.	R.	B. & M.		
	Dorothy Lake	Yosemite N.P.	30	4N	22E	MD	D	Scheelite Tucker & Sampson (41)581
	Sivori Group (Tungstar, Iron King, Hunch, Lime Cap) Lucky Strike Group (Mammoth, Lucky Strike, Little Wonder) (Confidence Mining District)	Sivori	12,14	2N	16E	MD	D	Scheelite in tactite and veins Little, J.M. (42)

YUBA COUNTY

NO.	NAME OF CLAIM	NAME OF OWNER	LOCATION				CLASS BY PROD.	REMARKS AND REFERENCES
			SEC.	T.	R.	B. & M.		
	Stephens (Dobbins Ranch)	R.E. Stephens et al	7	17N	7E	MD	D	Scheelite Quartz vein in gabbrodiorite (E D)

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SPECIAL ARTICLES

Detailed technical reports on special subjects, the result of research work or extended field investigations, will continue to be issued as separate bulletins by the Bureau, as has been the custom in the past.

Shorter and less elaborate technical papers and articles by members of the staff and others are published in each number of CALIFORNIA JOURNAL OF MINES AND GEOLOGY.

These special articles cover a wide range of subjects both of historical and current interest; descriptions of new processes, or metallurgical and industrial plants, new mineral occurrences, and interesting geological formations, as well as articles intended to supply practical and timely information on the problems of the prospector and miner, such as the text of new laws and official regulations and notices affecting the mineral industry.

BIENNIAL REPORT OF THE STATE MINERALOGIST

HON. KENNETH I. FULTON, Director,
Department of Natural Resources,
Sacramento, California.

Sir: Herein I have the honor to present the biennial report of the State Mineralogist as required by law, for transmittal to His Excellency, Governor Culbert L. Olson, covering the work and activity of the Division of Mines of the Department of Natural Resources, for the period July 1, 1940, to June 30, 1942.

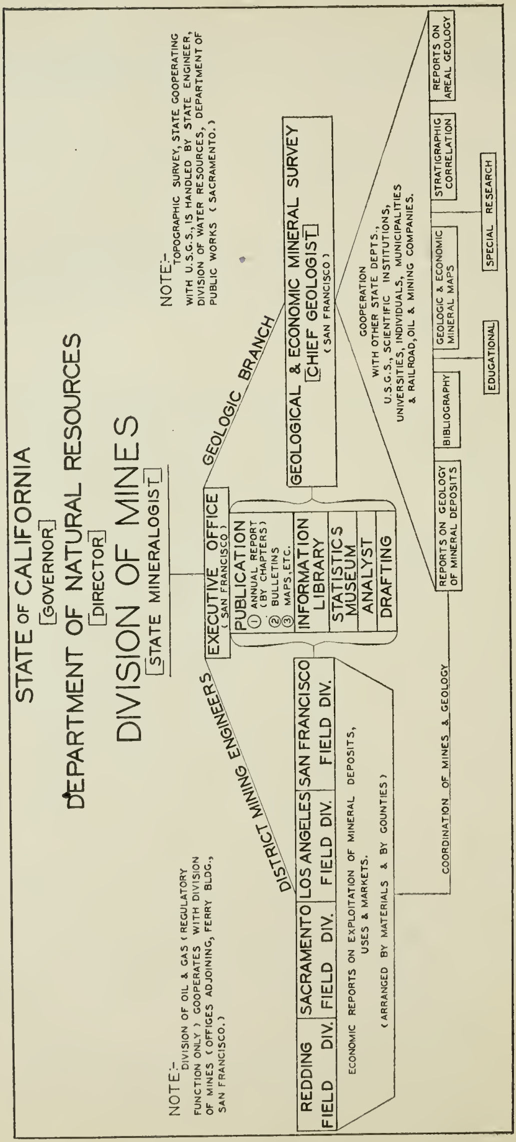
General Summary

As detailed in our report of two years ago, this division of California's State governmental activity has now had an unbroken history of sixty-two years since its creation by legislative enactment as the "State Mining Bureau," signed by Governor George C. Perkins, April 16, 1880. It was included as a division of the Department of Natural Resources, when the department was created by the legislature in 1927.

The organization chart made a part hereof shows the present-day set-up of the Division, its relation to other divisions of the department and its cooperation and coordination with other institutions or surveys, Federal, State, and educational. With reference to our cooperative and coordinated endeavors with other related institutions, I am pleased to say that we have had and are enjoying the most cordial and appreciated relations with such groups as the U. S. Geological Survey, U. S. Bureau of Mines, other Federal institutions (specifically, the Reconstruction Finance Corporation and its Metals Reserve Company, also the War Production Board), the geological and mining engineering departments of the several universities in California (as well as some outside of this State, whose men have done professional work within our borders), also with the operating mining and oil companies throughout California.

Besides the main headquarters with offices in the Ferry Building, San Francisco, including the library, laboratory, and mineral exhibits, district mining engineers are stationed with offices at Sacramento, Los Angeles, and Redding. Reports and bulletins to a total number of over 160 have been published from time to time describing in detail (with maps, charts, and photographs) the varied mineral substances available in this great commonwealth of California—their location, character, transportation facilities, state of development, utilization, and other pertinent facts.

This State is an extensive empire and has widespread and diversified resources of minerals not excelled by any other equal area on the face of the planet. It is a big task for the small staff of the Division to adequately cover this large assignment and keep up-to-date on the


STATE OF CALIFORNIA
[GOVERNOR]
DEPARTMENT OF NATURAL RESOURCES
[DIRECTOR]
DIVISION OF MINES
[STATE MINERALOGIST]
NOTE:- DIVISION OF OIL & GAS (REGULATORY FUNCTION ONLY) COOPERATES WITH DIVISION OF MINES (OFFICES ADJOINING, FERRY BLDG., SAN FRANCISCO.)
NOTE:- TOPOGRAPHIC SURVEY, STATE COOPERATING WITH U.S.G.S., IS HANDLED BY STATE ENGINEER, DIVISION OF WATER RESOURCES, DEPARTMENT OF PUBLIC WORKS (SACRAMENTO.)
DISTRICT MINING ENGINEERS
GEOLOGIC BRANCH
EXECUTIVE OFFICE (SAN FRANCISCO)
PUBLICATION
① ANNUAL REPORT (BY CHAPTERS)
② BULLETINS
③ MAPS, ETC.
INFORMATION LIBRARY
STATISTICS MUSEUM
ANALYST
DRAFTING
REDDING FIELD DIV.
SACRAMENTO FIELD DIV.
LOS ANGELES FIELD DIV.
SAN FRANCISCO FIELD DIV.
ECONOMIC REPORTS ON EXPLOITATION OF MINERAL DEPOSITS, USES & MARKETS.
(ARRANGED BY MATERIALS & BY COUNTIES)
COORDINATION OF MINES & GEOLOGY
GEOLOGICAL & ECONOMIC MINERAL SURVEY
[CHIEF GEOLOGIST]
(SAN FRANCISCO)
COOPERATION WITH OTHER STATE DEPTS., U.S.G.S., SCIENTIFIC INSTITUTIONS, UNIVERSITIES, INDIVIDUALS, MUNICIPALITIES & RAILROAD, OIL & MINING COMPANIES.
REPORTS ON GEOLOGY OF MINERAL DEPOSITS
BIBLIOGRAPHY
GEOLOGIC & ECONOMIC MINERAL MAPS
STRATIGRAPHIC CORRELATION
REPORTS ON AREAL GEOLOGY
EDUCATIONAL
SPECIAL RESEARCH

economic developments in all of the varied mineral industries and areas within our borders. Since the beginning of war operations in Europe and especially since December 7, 1941, with entrance of the United States into the conflict, much attention is being given to inventorying and developing our domestic resources of certain ''strategic'' minerals important to the United States in our National defense and war program. These include specifically quicksilver, manganese, tungsten, antimony, chromite, magnesium, as well as others, of which California has both currently active and potential resources. In fact, even before September, 1939, the Division of Mines had begun re-surveys of California's resources of certain of the foregoing substances to bring our information up-to-the-minute with bulletins and maps available to the public; and in the October, 1939 chapter of the State Mineralogist's Report published the first of this new series, on Quicksilver, including a State-wide map with basic geologic data showing all known occurrences and operations in the State. As it is tied in on its base with the geology, it gives a clue to the favorable areas for prospecting for new deposits or for extensions of the orebodies of known operations. A similar map and reports have been made available on Chromite, also Petroleum, one on Tungsten is in press, and others are in process on Manganese, Copper, Iron, and Zinc. A list is included elsewhere herein of the papers, bulletins, reports, maps, and other publications issued during this biennial period.

In September, 1941, under regulations for priorities on machinery and supplies, the War Production Board promulgated Order P-56 covering mining operations, with Mr. Wilbur Nelson, as Coordinator for Mines in the Washington headquarters. In each of the States an Emergency Coordinator for Mines was appointed by the Governor, to handle applications and other matters dealing with priorities for mines. Our director of the Department of Natural Resources, Mr. Kenneth I. Fulton, being appointed for California, assigned these duties to the Division of Mines. Lists of all operating mines in the State were furnished Washington from our Division files and records, based upon which priority permits were issued. Placer gold operations (with an A-10 rating) were excluded from the benefits of the A-8 rating under Order P-56, and permits were not issued to mines employing less than ten men. However, the 10-man restriction was modified for some cases of strategic, war-needed minerals. A total of 414 permit numbers under P-56 have thus far been issued to Californian mines, all applications for such and the attendant correspondence being handled by the State Mineralogist as liaison for the Emergency Coordinator. In March, 1942, the P-56 priority permits for gold mines were canceled, with the exception of a limited number whose ores or concentrates are required by the lead and copper smelters as a flux or diluent.

The clerical, cataloguing, indexing, and map-making project under assistance of the renewed W.P.A. grant has continued with a smaller personnel (maximum of 18) during the past two years. A series of abstracts, by substances, of a long list of California's mineral products have been prepared and reference copies provided for each of the Division's offices compiled on a State-wide basis from the published bulletins and reports of the Division over the past sixty years. Because of a popular demand for these abstracts, the following were mimeographed and made available for public sale: Iron, Pumice and Volcanic Ash, Sulphur, Tungsten. One of the important items on our W.P.A. program has been the binding of a large number of pamphlets, paper-covered books, and magazine files which will be a permanent asset in the library of the Division. We are informed that all W.P.A. projects will close before the end of the current calendar year, as no further appropriations for them are being made.

Laboratory

The Mineral Technologist reports that the laboratory of the Division headquarters has identified and classified approximately 18,000 samples mailed or brought into the Division. A written laboratory report is given on each sample, and commercial possibilities, if any, are noted. These reports are further supplemented by reports concerning the preparation of the ore mineral in question, markets and possible buyers. These samples were mainly from the southern counties of the State, although samples were received from all of California's fifty-eight counties. Due to the increase of material sent in for identification because of the natural increase in the Division's business, plus the tremendous activity in the field in the search for stategic minerals needed for war use, it was found necessary to curtail the number of determinations that could be made from three to two samples per month from each citizen of California. In other words, only two-thirds of the work that could have been accomplished by the laboratory was done because of insufficient appropriations for labor and supplies, which were anticipated and requested in our last budget. However, as a result of these determinations it was found that many hundreds of samples, fully ten per cent, had commercial possibilities. This information was made available to the public through our files and our own Monthly Commercial Mineral Notes.

The laboratory has aided many mineral collectors in identifying specimen material, although not as much as in past years because of the need to devote all of our time to war samples. The laboratory has represented the Division at California county fairs to judge mineral exhibits, and has had a testing laboratory at the fairs, and whenever called upon has furnished a speaker to address various luncheon clubs and other groups who are interested in the mining industry of California.

The work done by the laboratory in instruction in mineralogy and prospecting, given to the veterans of the Mt. Diablo and San Ramon C.C.C. Camps in Contra Costa County, has been brought to a close. This additional program was in charge of Mr. George L. Gary, our Mineral Technologist; and through these classes 51 men were graduated and employment was secured for all of them in the mining industry in this State.

This same laboratory and equipment that were used in this work are now being used to train men to prospect for strategic minerals needed by the Government. This new class has only been under way a few months but the results have been very encouraging. The students are of the executive type, holding responsible jobs or owning their own businesses; and the attendance has been remarkable in view of the demands made upon their time due to the war. One man from this class has already been drafted as a field engineer by the Kaiser Engineering Company, and another man is expected to go with them as a chemist within the next few weeks. It is a potential reservoir of manpower that may be used in field or plant duty by the mineral industry.

The instruction in mineralogy is divided into four parts. The first part consists of blackboard lectures on the identification of rocks and the origin, occurrence, and association of minerals. The second part consists of the identification of all the strategic and commercial minerals. The third part consists of the chemical examination of minerals and the general principles of chemistry as applied to minerals. The fourth part of the work consists of field trips to the geological provinces of the State where commercial minerals are found, and brings the men in contact with operations.

Approximately 50 articles have been written by the Mineral Technologist upon all of the commercial minerals of California, giving the properties, occurrences, preparation, uses, tests, markets, possible buyers, and bibliography of these minerals. These articles have been mimeographed and up to 15,000 copies of individual papers have been circulated throughout the State to people interested in developing the mineral resources of California. They are to be found in public libraries and universities; and many newspapers and magazines in the technical field have secured permission from this Division to reprint these articles. This was largely made possible by work contributed by the Federal Work Projects Administration of which our Mineral Technologist is the Technical Director.

Special articles have also been written by the Mineral Technologist for the Quarterly Report of the State Mineralogist and other magazines dealing with pertinent information on minerals and their uses.

Geologic Branch

As previously outlined, a definite and practical plan of work has been consistently followed by the Geologic Branch, resulting in creditable progress during the past two years. Its salient points are:

(1) To continue geologic mapping of areas not hitherto adequately considered.

(2) To encourage geologic research workers (especially those associated with our universities) to make systematic investigations of worth-while problems regarding the geology and mineral resources of the State.

(3) To act as a clearing-house for geologic information concerning California.

(4) To release to the public valuable reports which have been carefully prepared, but not yet published.

(5) To carry on state-wide investigations, especially those of importance as an aid to the progress of national defense and the war.

(6) To prepare a series of state maps (using the same base as that of the Geologic Map of California) to show the distribution and evaluation of economic minerals (such as those on quicksilver, oil, chromite, recently issued).

(7) To submit for publication the results of work as soon as they can be put in proper shape for printing.

Dr. Olaf P. Jenkins lists the following papers and reports of the Geologic Branch published during this biennium, and their authors:

''General Geology and Ores of the Blind Spring Hill Mining District, Mono County, California'', by Alfred L. Ransome (Cal. Jour. Mines and Geol., April, 1940, pp. 159-197, 27 figs.)

''Geology of the Newberry and Ord Mountains, San Bernardino County, California'', by Dion L. Gardner (Cal. Jour. Mines and Geol., July 1940, pp. 257-292, 9 figs., map pl. II).

''Notes on the Geology of a Portion of the Calico Mountains, San Bernardino County, California'', by Homer D. Erwin and Dion L. Gardner (Cal. Jour. Mines and Geol., July 1940, pp. 293-304, map pl. III).

''Strategic Problems of the Mineral Industry in California'', by Olaf P. Jenkins (Cal. Jour. Mines and Geol., October 1940, pp. 335-341).

''Descriptive Geology of the Kernville Quadrangle, California'', by William J. Miller and Robert W. Webb (Cal. Jour. Mines and Geol., October 1940, pp. 343-378, 31 figs., map pl. II).

''Geology of the Big Blue Group of Mines, Kernville, California'', by John W. Prout, Jr. (Cal. Jour. Mines and Geol., October 1940, pp. 379-421, 22 figs., pl. III).

''Strategic Minerals Procurement'', by Charles White Merrill (Cal. Jour. Mines and Geol., January 1941, pp. 91-100).

''Geological Investigation of the Chromite Deposits of California,'' by John Eliot Allen (Cal. Jour. Mines and Geol., January 1941, pp. 91-100).

''Geological Progress of the California State Division of Mines, 1930 to 1940,'' by Olaf P. Jenkins (Cal. Jour. Mines and Geol., April 1941, pp. 205-217).

''California Earthquakes of the Mission Period, 1769-1838,'' by Robert F. Heizer (Cal. Jour. Mines and Geol., April 1941, pp. 219-223).

''Occurrence of Scheelite in Idaho-Maryland Mines at Grass Valley, California,'' by Rollin Farmin (Cal. Jour. Mines and Geol., April 1941, p. 224).

''Tungsten Resources of California,'' by John F. Partridge, Jr. (Cal. Jour. Mines and Geol., April 1941, pp. 225-325, 20 figs.).

''Tin in California,'' by Richard J. Segerstrom (Cal. Jour. Mines and Geol., October 1941, pp. 531-557, 4 figs., bibliography prepared by Elisabeth L. Egenhoff).

''California Quicksilver Program of the Federal Geological Survey,'' by Edwin B. Eckel (Cal. Jour. Mines and Geol., October 1941, pp. 558-563).

''Bulletin 118—Geologic Formations and Economic Development of the Oil and Gas Fields of California,'' prepared under the direction of Olaf P. Jenkins.

PART ONE—Development of the Industry—contains the following reports:

''Economics of the Oil and Gas Industry of California,'' by J. R. Pemberton, pp. 3-14, 2 figs.

''Taxation and Its Relation to Development and Production,'' by Granville S. Borden, pp. 15-16.

''Historical Production Chart,'' by H. L. Scarborough, plate I.

''Stocks Chart,'' by H. L. Scarborough, fig. 3.

''Shipments Chart,'' by H. L. Scarborough, fig. 4.

''Significant Statistics Characteristic of Crude Oil Production of California,'' by Wm. R. Wardner, pp. 20-25.

''Analysis of California Petroleum Reserves and Their Relation to Demand and Curtailment,'' by Wm. R. Wardner, pp. 26-32, 7 figs.

''Natural Gas Fields of California,'' by Roy M. Bauer and John F. Dodge, pp. 33-36, 2 figs.

''Development of Engineering Technique and Its Effect upon Exploration for Oil and Gas in California,'' by Lester C. Uren, pp. 39-62, 17 figs.

''Mechanics of California Reservoirs,'' by Stanley C. Herold, pp. 63-66, 4 figs.

''Geophysical Studies in California,'' by F. E. Vaughan, pp. 67-70, 1 fig.

''Geochemical Prospecting for Petroleum,'' by E. E. Rosaire, pp. 71-72, 1 fig.

''Aboriginal Use of Bitumen by the California Indians,'' by Robert F. Heizer, p. 74, 1 fig.

''History of Exploration and Development of Gas and Oil in Northern California,'' by Walter Stalder, pp. 75-80, 1 fig.

PART TWO—Geology of California and the Occurrence of Oil and Gas—includes the following reports:

''Geomorphic Provinces of California,'' by Olaf P. Jenkins, pp. 83-88, 3 figs.

''Salient Geologic Events in California and Their Relationship to Mineral Deposition,'' by Olaf P. Jenkins, pp. 89-94, 5 figs.

''Position of the California Oil Fields as Related to Geologic Structure,'' by Ralph D. Reed, pp. 95-97, 2 figs.

''California's Record in the Geologic History of the World,'' by Ralph D. Reed, pp. 99-118, 10 figs.

''Geologic History and Structure of the Central Coast Ranges of California,'' by N. L. Taliaferro, pp. 119-162, structure sections pl. II.

''Characteristic Fossils of California,'' by G. Dallas Hanna and Leo George Hertlein, pp. 165-182, 8 figs.

''Descriptions of Foraminifera,'' by C. C. Church, p. 182.

''Synopsis of the Later Mesozoic in California,'' by F. M. Anderson, pp. 183-186, 2 figs.

''Notes on California Tertiary Correlation,'' by Bruce L. Clark, pp. 187-191.

''Eocene Foraminiferal Correlations in California,'' by Boris Laiming, pp. 193-198, 9 figs.

''Chart Showing Sequence of Oligocene Formations in California,'' by Lesh C. Forrest, pp. 199-200, chart pl. III.

''Correlation Chart of the Miocene of California,'' by Robert M. Kleinpell; ''Introduction'' by William D. Kleinpell; p. 200, chart pl. IV.

''Pliocene Correlation Chart,'' by U. S. Grant IV and Leo George Hertlein, pp. 201-202, 1 fig.

''The Pleistocene in California,'' by J. E. Eaton, pp. 203-206, 1 fig.

''Stratigraphic Relations of the Producing Zones of the Los Angeles Basin Oil Fields,'' by Stanley G. Wissler, pp. 209-234, 7 figs., chart pl. V.

''Correlation of the Oil Fields of the Santa Maria District,'' by Stanley G. Wissler and Frank E. Dreyer, pp. 235-238, 1 fig.

''Correlation of Oil Field Formations on East Side San Joaquin Valley,'' by Glenn C. Ferguson, pp. 239-246, 3 figs.

''Correlation of Oil Field Formations on West Side of San Joaquin Valley,'' by Paul P. Goudkoff, pp. 247-252, 3 figs.

''Origin, Migration, and Accumulation of Oil in California,'' by Harold W. Hoots, pp. 253-275, 12 figs., map pl. VI.

''Economic Mineral Map of California No. 2—Oil and Gas,'' prepared under the direction of Olaf P. Jenkins, 1941.

''Economic Mineral Map of California No. 3—Chromite,'' prepared under the direction of Olaf P. Jenkins, 1942.

Reports of the Geologic Branch in Press, to Be Published During 1942 or Early in 1943

''Geology and Mineral Deposits of the Cargo Muchacho Mountains, Imperial County, California,'' by Paul C. Henshaw (Cal. Jour. Mines and Geol., April 1942).

''Hot Spring Deposits of the Coso Mountains,'' by H. J. Fraser (Cal. Jour. Mines and Geol., July-October 1942).

''Tabulated List of Tungsten Properties to Accompany Economic Mineral Map. No. 4—Tungsten'', by Olaf P. Jenkins (Cal. Jour. Mines and Geol., July-October 1942).

''Economic Mineral Map No. 4—Tungsten'', prepared under the direction of Olaf P. Jenkins (Cal. Jour. Mines and Geol., July-October 1942, in pocket).

''Geology of Twin Lakes, Near Huntington Lake'', by C. W. Chesterman (Cal. Jour. Mines and Geol., July-October 1942).

''Economic Mineral Map No. 5—Manganese'', prepared under the direction of Olaf P. Jenkins.

PART THREE, Bulletin 118—''Descriptions of Individual Oil and Gas Fields'', consisting of Chapters VIII to XIII, pages 277-664.

PART FOUR of Bulletin 118—"Glossaries, Bibliography, and Index", consisting of Chapters XIV to XVI.

Total number of pages in the book, (Bulletin 118), approximately 750; total number of authors, approximately 120.

Through cooperation with many agencies (university geologists, federal, commercial, and other outstanding authorities) the Geologic Branch has under way a large number of projects. These consist of preparation of reports on (a) special areas or problems, (b) state-wide studies of economic mineral resources, (c) preparation of state-wide maps showing the distribution of certain minerals, (d) continuation of the geologic mapping of the state, (e) continuous revision of "Minerals of California", (f) preparation of a bulletin on the rocks of California, (g) preparation of a bulletin on the geology of California.

The results of the program of state-wide work by the Geologic Branch have proved to be most desired by the largest number of people interested in the mineral industry. The various federal agencies engaged in this study during this war, have repeatedly expressed their gratitude for the work we have accomplished. These agencies include: U. S. Geological Survey, U. S. Bureau of Mines, U. S. Bureau of Reclamation, War Production Board, Reconstruction Finance Corporation, Office of Price Administrator, Metals Reserve Company, and U. S. Forest Service. They have all cooperated in our work. Also, the War Department has several times come to the Geologic Branch for advice on water supply, and problems which involve the relationship of geology to engineering.

The Geologic Branch has been very busy, indeed. In our office, there is imperative need of at least one stenographer. It is poor economy to require our technical staff of three (Chief Geologist, Geological Clerk, and Geological Draftsman) to handle work which could be done by a typist. Our working quarters are small and crowded, and our equipment is limited to the extreme. We have no young assistant geologist to assign to field problems which are continually appearing before us. If it were not for the whole-hearted support from outside engineers and geologists, we would not have to our credit the above list of published works. Bulletin 118 alone (with 120 contributors) is the largest and most detailed book ever published by the Division of Mines, and the most complete treatise of its kind in the United States. Our state-wide mineral maps are the envy of many other state geological surveys.

Ore Buyers' Inspection

During the years 1940 and 1941 several thousand dollars were recovered from various individuals apprehended in stealing gold from different gold properties. In some cases where the gold was recovered, there were no prosecutions—and in other cases, probation was granted. During the year 1942, highgrading from the gold mines has fallen off to a minimum, due to the activities of the Ore Buyer's Inspector's work in cooperation with the U. S. Secret Service. A total of $1100.00 in fines was imposed for highgrading activities, and an aggregate five years' prison terms to the several individuals convicted.

The total number of Ore Buyers licensed in 1940 was 184; in 1941, 186; and in 1942, 161 thus far.

In October 1941, the Division of Mines having been assigned the duty of liasion with the War Production Board in handling priority matters for mines in California, the detailed work was put in the hands of the ore-buyers' inspector. Through the work in this office, a total of 414 numbers were issued to mines in California to assist them in obtaining equipment for the operation of these various properties. A complete detailed file is kept in this office and any information desired about a specific property may be obtained from a card index kept. Even though numbers have not been issued in numerous cases, the history of the efforts made to effect obtaining such numbers is completely marked on each card. Complete data are also filed under the substance produced as well as alphabetically arranged.

PUBLICATIONS

Publications issued July 1, 1940 to June 30, 1942:

July and October chapters (California Journal of Mines and Geology) of State Mineralogist's Report XXXVI. Among the more important subjects are:

Economic Mineral Deposits of the Newberry and Ord Mountains, San Bernardino County.
Geology of the Newberry and Ord Mountains, San Bernardino County.
Notes on the Geology of a Portion of the Calico Mountains, San Bernardino County.
Mineral Resources of the Kernville Quadrangle.
Strategic Problems of the Mineral Industry in California.
Descriptive Geology of the Kernville Quadrangle (with map).
Geology of the Big Blue Group of Mines, Kernville, California.

Special Articles on:

Study of Chrome Process Aided by Martin Dennis Company.
Biennial Report of the State Mineralogist.
Strategic Metals Tax Exemption.
Federal Loans for Strategic Minerals.

State Mineralogist's Report XXXVII, 1941. Among the more important subjects included are:

Mineral Resources of Trinity County, (with map).
Strategic Minerals Procurement.
Geologic Investigation of the Chromite Deposits of California.
Geologic Progress of the California State Division of Mines, 1930-1940.
California Earthquakes of the Mission Period, 1769-1838.
Occurrence of Scheelite in Idaho-Maryland Mine at Grass Valley, California.
Tungsten Resources of California.
Mineral Resources of Nevada County (with maps).
Mineral Resources of Humboldt County.
Tin in California.
California Quicksilver Program of the Federal Geological Survey.

Special Articles on:

United States Supreme Court Renders Far-reaching Decision on Power Permits on "Navigable" Streams.
Securities and Exchange Commission.
Dragline Dredging in Siskiyou County.
Marketing Talc, Pyrophyllite and Ground Soapstone.
Manganese.
Magnesite.
History of the Names Cobalt and Nickel.
Aluminum.
Quartz.
New Mining Laws.
Recent Developments in the Tungsten Resources of California.
New Manganese and Chrome Ore Specifications and Prices.
Does Scheelite always Fluoresce?
Bentonite.

January and April, 1942, chapters (California Journal of Mines and Geology), of State Mineralogist's Report XXXVIII. Among the more important subjects included are:

Mines and Mineral Resources of Sierra County.
Mineral Resources of Imperial County (with map).
Geology and Mineral Deposits of the Cargo Muchacho Mountains, Imperial County (with map).

Special Articles on:

Chromium.
Imperial Carbon Dioxide Gas Field.
The Legendary "White Metal" and its "Ore."
Mine Assessment Work Suspended on Claims Within Withdrawn Areas.

Bulletin 118. Geologic Formations and Economic Development of the Oil and Gas Fields of California. Prepared under the direction of Olaf P. Jenkins.

Preprint of Part I, Development of the Industry.
Preprint of Part II, Geology of California, and the Occurrence of Oil and Gas.

Bulletin 119. California Mineral Production and Directory of Mineral Producers for 1939, by Henry H. Symons, 223 pages, 9 illustrations. Gives detailed figures of commercial production of all mineral substances in California for the calendar year, 1939.

Bulletin 120. Manner of Locating and Holding Mineral Claims in California, by A. H. Ricketts, with Revisions by C. McK. Laizure, 26 pages, 1 illustration. This is in reality a sixth edition of the popular Bulletin 106, with the addition of new statutory requirements passed since 1935.

Bulletin 121. California Mineral Production and Directory of Mineral Producers for 1940, by Henry H. Symons, 227 pages, 12 illustrations. Gives detailed figures of commercial production of all mineral substances in California for the calendar year, 1940.

Conclusion

As the only State agency in California fostering the economic development of our diversified and vital mineral resources, the Division of Mines deserves generous support for the continued and even an expanded maintenance of its service to the public and these industries now so vital in the present war-time crisis. Particularly should this support be manifested in the allocation of adequate funds for field work by the division's engineers and geologists and for the printing of reports and maps. The moneys spent on printing come back to the State Treasury from the sales of the publications.

Respectfully submitted.

WALTER W. BRADLEY,
State Mineralogist.

September 15, 1942.

PRODUCERS AND CONSUMERS

The producer and consumer of mineral products are mutually dependent upon each other for their prosperity, and one of the most direct aids rendered by this Division to the mining industry in the past has been that of bringing producers and consumers into direct touch with each other.

This work has been carried on largely by correspondence, supplemented by personal consultation. Lists of buyers of all the commercial minerals produced in California have been made available to producers upon request, and likewise the owners of undeveloped deposits of various minerals, and producers of them, have been made known to those looking for raw mineral products.

When the publication of *Mining in California* was on a monthly basis, current inquiries from buyers and sellers were summarized and lists of mineral products or deposits 'wanted' or 'for sale' included in each issue.

It is important that inquiries of this nature reach the mining public as soon as possible and in order to avoid the delay incident to the present quarterly publication of CALIFORNIA JOURNAL OF MINES AND GEOLOGY, these lists are now issued monthly in the form of a mimeographed sheet under the title of 'Commercial Mineral Notes,' and sent to those on the mailing list of CALIFORNIA JOURNAL OF MINES AND GEOLOGY.

EMPLOYMENT SERVICE

Following the establishment of the Mining Division branch offices in 1919, a free technical employment service was offered as a mutual aid to mine operators and technical men for the general benefit of the mineral industry.

Briefly summarized, men desiring positions are registered, the cards containing an outline of the applicant's qualifications, position wanted, salary desired, etc., and as notices of 'positions open' are received, the names and addresses of all applicants deemed qualified are sent to the prospective employer for direct negotiations.

Telephone and telegraphic communications are also given immediate attention.

Technical men, or those qualified for supervisory positions, and vacancies of like nature only, are registered, as no attempt will be made to supply common mine and mill labor.

Registration cards for the use of both prospective employers and employees may be obtained upon request, and a cordial invitation is extended to the industry to make free use of the facilities afforded. Parties interested should communicate direct with our San Francisco office.

PUBLICATIONS OF THE DIVISION OF MINES

During the past sixty-two years, in carrying out the provisions of the organic act creating the former California State Mining Bureau, there have been published many reports, bulletins and maps which go to make up a library of detailed information on the mineral industry of the State, a large part of which could not be duplicated from any other source.

One feature that has added to the popularity of the publications is that many of them have been distributed without cost to the public, and even the more elaborate ones have been sold at a price which barely covers the cost of printing.

Owing to the fact that funds for the advancing of the work of this department have usually been limited, the reports and bulletins mentioned are printed in limited editions many of which are now entirely exhausted.

Copies of such publications are available for reference, however, in the offices of the Division of Mines, in the Ferry Building, San Francisco; State Building, Los Angeles; State Office Building, Sacramento; Redding; and Division of Oil and Gas at Santa Barbara, Santa Paula, Taft, Bakersfield, Coalinga. They may also be found in many public, private and technical libraries in California and other states and foreign countries.

A catalog of all publications from 1880 to 1917, giving a synopsis of their contents, is issued as Bulletin No. 77.

Publications in stock may be obtained postpaid by addressing the San Francisco, Los Angeles or Sacramento offices and enclosing the requisite amount.

Remittances of stamps in an amount not to exceed 26 cents, currency or coin will be accepted at sender's risk. Payment is preferred in the form of money orders.

Money orders should be made payable to the Division of Mines.

NOTE.—The Division of Mines frequently receives requests for some of the early Reports and Bulletins now out of print, and it will be appreciated if parties having such publications and wishing to dispose of them will advise this office.

Write for latest revised price list.

REPORTS

Asterisks (**) indicate the publication is out of print.	Price (including postage and sales tax)
**First Annual Report of the State Mineralogist, 1880, 43 pp. Henry G. Hanks	----
**Second Annual Report of the State Mineralogist, 1882, 514 pp., 4 illustrations, 1 map. Henry G. Hanks	----
**Third Annual Report of the State Mineralogist, 1883, 111 pp., 21 illustrations. Henry G. Hanks	----
**Fourth Annual Report of the State Mineralogist, 1884, 410 pp., 7 illustrations. Henry G. Hanks	----
**Fifth Annual Report of the State Mineralogist, 1885, 234 pp., 15 illustrations, 1 geological map. Henry G. Hanks	----
Sixth Annual Report of the State Mineralogist, Part I, 1886, 145 pp., 3 illustrations, 1 map. Henry G. Hanks Price $0.75, sales tax $0.02	$0.77
Part II, 1887, 222 pp., 36 illustrations. William Irelan, Jr. Price $0.75, sales tax $0.02	.77
**Seventh Annual Report of the State Mineralogist, 1887, 315 pp. William Irelan, Jr.	----
**Eighth Annual Report of the State Mineralogist, 1888, 948 pp., 122 illustrations. William Irelan, Jr.	----
**Ninth Annual Report of the State Mineralogist, 1889, 352 pp., 57 illustrations, 2 maps. William Irelan, Jr.	----
**Tenth Annual Report of the State Mineralogist, 1890, 983 pp., 179 illustrations, 10 maps. William Irelan, Jr.	----
Eleventh Report (First Biennial) of the State Mineralogist, for the two years ending September 15, 1892, 612 pp., 73 illustrations, 4 maps. William Irelan, Jr. Price $1.50, sales tax $0.05	1.55
**Twelfth Report (Second Biennial) of the State Mineralogist, for the two years ending September 15, 1894, 541 pp., 101 illustrations, 5 maps. J. J. Crawford	----
**Thirteenth Report (Third Biennial) of the State Mineralogist, for the two years ending September 15, 1896, 726 pp., 93 illustrations, 1 map. J. J. Crawford	----
Chapters of the State Mineralogist's Report, XIV Biennial Period, 1913-1914, Fletcher Hamilton:	
**Mines and Mineral Resources, Amador, Calaveras and Tuolumne Counties, 172 pp., paper	----
Mines and Mineral Resources, Colusa, Glenn, Lake, Marin, Napa, Solano, Sonoma and Yolo Counties, 208 pp., paper Price $0.75, sales tax $0.02	.77
**Mines and Mineral Resources, Del Norte, Humboldt and Mendocino Counties, 59 pp., paper	----
**Mines and Mineral Resources, Fresno, Kern, Kings, Madera, Mariposa, Merced, San Joaquin and Stanislaus Counties, 220 pp., paper	----
**Mines and Mineral Resources of Imperial and San Diego Counties, 113 pp., paper	----
**Mines and Mineral Resources, Shasta, Siskiyou and Trinity Counties, 180 pp., paper	----
**Fourteenth Report of the State Mineralogist, for the Biennial Period 1913-1914, Fletcher Hamilton, 1915: A General Report on the Mines and Mineral Resources of Amador, Calaveras, Tuolumne, Colusa, Glenn, Lake, Marin, Napa, Solano, Sonoma, Yolo, Del Norte, Humboldt, Mendocino, Fresno, Kern, Kings, Madera, Mariposa, Merced, San Joaquin, Stanislaus, San Diego, Imperial, Shasta, Siskiyou and Trinity Counties, 974 pp., 275 illustrations, cloth	----
Chapters of the State Mineralogist's Report, XV Biennial Period, 1915-1916, Fletcher Hamilton:	
**Mines and Mineral Resources, Alpine, Inyo and Mono Counties, 176 pp., paper	----
Mines and Mineral Resources, Butte, Lassen, Modoc, Sutter and Tehama Counties, 91 pp., paper Price $0.75, sales tax $0.02	.77

REPORTS—Continued

Asterisks (**) indicate the publication is out of print.

	Price (including postage and sales tax)
Mines and Mineral Resources, El Dorado, Placer, Sacramento and Yuba Counties, 198 pp., paper Price $0.75, sales tax $0.02	$0.77
Mines and Mineral Resources, Monterey, San Benito, San Luis Obispo, Santa Barbara and Ventura Counties, 183 pp., paper Price $0.75, sales tax $0.02	.77
**Mines and Mineral Resources, Los Angeles, Orange and Riverside Counties, 136 pp., paper	----
**Mines and Mineral Resources, San Bernardino and Tulare Counties, 186 pp., paper	----
**Fifteenth Report of the State Mineralogist, for the Biennial Period 1915-1916, Fletcher Hamilton, 1917: A General Report on the Mines and Mineral Resources of Alpine, Inyo, Mono, Butte, Lassen, Modoc, Sutter, Tehama, Placer, Sacramento, Yuba, Los Angeles, Orange, Riverside, San Benito, San Luis Obispo, Santa Barbara, Ventura, San Bernardino and Tulare Counties, 990 pp., 413 illustrations, cloth	----
Chapters of the State Mineralogist's Report XVI, Biennial Period, 1917-1918, Fletcher Hamilton:	
Mines and Mineral Resources of Nevada County, 270 pp., paper Price $1.00, sales tax $0.03	1.03
Mines and Mineral Resources of Plumas County, 188 pp., paper Price $0.75, sales tax $0.02	.77
Mines and Mineral Resources of Sierra County, 144 pp., paper Price $0.75, sales tax $0.02	.77
Seventeenth Report of the State Mineralogist, 1920, 'Mining in California during 1920,' Fletcher Hamilton; 562 pp., 71 illustrations, cloth Price $2.50, sales tax $0.08	2.58
Eighteenth Report of the State Mineralogist, 1922, 'Mining in California,' Fletcher Hamilton. Chapters published monthly beginning with January, 1922:	
**January, **February, **March, **April, May, June, July, August, September, October, November, December, 1922 Price $0.40, sales tax $0.01	.41
Chapters of Nineteenth Report of the State Mineralogist, 'Mining in California,' Fletcher Hamilton and Lloyd L. Root. January, February, March, September, 1923 Price $0.40, sales tax $0.01	.41
Chapters of Twentieth Report of the State Mineralogist, 'Mining in California,' Lloyd L. Root. Published quarterly. January, April, July, October, 1924, per copy Price $0.40, sales tax $0.01	.41
Chapters of Twenty-first Report of the State Mineralogist, 'Mining in California,' Lloyd L. Root. Published quarterly:	
January, 1925, Mines and Mineral Resources of Sacramento, Monterey and Orange Counties Price $0.40, sales tax $0.01	.41
April, 1925, Mines and Mineral Resources of Calaveras, Merced, San Joaquin, Stanislaus and Ventura Counties Price $0.40, sales tax $0.01	.41
**July, 1925, Mines and Mineral Resources of Del Norte, Humboldt and San Diego Counties	----
**October, 1925, Mines and Mineral Resources of Siskiyou, San Luis Obispo and Santa Barbara Counties	----
Chapters of Twenty-second Report of the State Mineralogist, 'Mining in California,' Lloyd L. Root. Published quarterly:	
**January, 1926, Mines and Mineral Resources of Trinity and Santa Cruz Counties	----
April, 1926, Mines and Mineral Resources of Shasta, San Benito and Imperial Counties Price $0.40, sales tax $0.01	.41
July, 1926, Mines and Mineral Resources of Marin and Sonoma Counties Price $0.40, sales tax $0.01	.41
**October, 1926, Mines and Mineral Resources of El Dorado and Inyo Counties, also report on Minaret District, Madera County	----

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Asterisks (**) indicate the publication is out of print.	Price (including postage and sales tax)
Chapters of Twenty-third Report of the State Mineralogist, 'Mining in California,' Lloyd L. Root. Published quarterly:	
January, 1927, Mines and Mineral Resources of Contra Costa County; Santa Catalina Island Price $0.40, sales tax $0.01	$0.41
April, 1927, Mines and Mineral Resources of Amador and Solano Counties Price $0.40, sales tax $0.01	.41
**July, 1927, Mines and Mineral Resources of Placer and Los Angeles Counties	----
October, 1927, Mines and Mineral Resources of Mono County Price $0.40, sales tax $0.01	.41
Chapters of Twenty-fourth Report of the State Mineralogist, 'Mining in California,' Lloyd L. Root. Published quarterly:	
January, 1928, Mines and Mineral Resources of Tuolumne County Price $0.40, sales tax $0.01	.41
April, 1928, Mines and Mineral Resources of Mariposa County Price $0.40, sales tax $0.01	.41
**July, 1928, Mines and Mineral Resources of Butte and Tehama Counties	----
October, 1928, Mines and Mineral Resources of Plumas and Madera Counties Price $0.40, sales tax $0.01	.41
Chapters of Twenty-fifth Report of the State Mineralogist, 'Mining in California,' Walter W. Bradley. Published quarterly:	
**January, 1929, Mines and Mineral Resources of Lassen, Modoc and Kern Counties; also on Special Placer Machines	----
**April, 1929, Mines and Mineral Resources of Sierra, Napa, San Francisco and San Mateo Counties	----
July, 1929, Mines and Mineral Resources of Colusa, Fresno and Lake Counties Price $0.40, sales tax $0.01	.41
October, 1929, Mines and Mineral Resources of Glenn, Alameda, Mendocino and Riverside Counties Price $0.40, sales tax $0.01	.41
Chapters of Twenty-sixth Report of the State Mineralogist, 'Mining in California,' Walter W. Bradley. Published quarterly:	
January, 1930, Mines and Mineral Resources of Santa Clara County; also Barite in California Price $0.40, sales tax $0.01	.41
**April, 1930, Mines and Mineral Resources of Nevada County; also Mineral Paint Materials in California	----
**July, 1930, Mines and Mineral Resources of Yuba and San Bernardino Counties; also Commercial Grinding Plants in California	----
October, 1930, Mines and Mineral Resources of Butte, Kings and Tulare Counties: also Geology of Southwestern Mono County (Preliminary) Price $0.40, sales tax $0.01	.41
Chapters of Twenty-seventh Report of the State Mineralogist, 'Mining in California,' Walter W. Bradley. Published quarterly:	
January, 1931. Preliminary Report of Economic Geology of the Shasta Quadrangle. Beryllium and Beryl. The New Tariff and Nonmetallic Products. Crystalline Talc. Decorative Effects in Concrete Price $0.40, sales tax $0.01	.41
April, 1931, Stratigraphy of the Kreyenhagen Shale. Diatoms and Silicoflagellates of the Kreyenhagen Shale. Foraminifera of the Kreyenhagen Shale. Geology of Santa Cruz Island Price $0.40, sales tax $0.01	.41
**July, 1931. (Yuba, San Bernardino.) Feldspar, Silica, Andalusite and Cyanide Deposits of California. Note on a Deposit of Andalusite in Mono County; its occurrence and chemical importance. Bill creating Trinity and Klamath River Fish and Game District and its effect upon mining	----
October, 1931. (Alpine.) Geology of the San Jacinto Quadrangle south of San Gorgonio Pass, California. Notes on Mining Activities in Inyo and Mono Counties in July, 1931 Price $0.40, sales tax $0.01	.41
Chapters of Twenty-eighth Report of the State Mineralogist, 'Mining in California,' Walter W. Bradley. Published quarterly:	

REPORTS—Continued

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	Price (including postage and sales tax)
January, 1932, Economic Mineral Deposits of the San Jacinto Quadrangle. Geology and Physical Properties of Building Stone from Carmel Valley. Contributions to the Study of Sediments. Sediments of Monterey Bay. Sanbornite — Price $0.40, sales tax $0.01	$0.41
**April, 1932. Elementary Placer Mining Methods and Gold Saving Devices. The Pan, Rocker and Sluice Box. Prospecting for Vein Deposits. Bibliography of Placer Mining	----
Abstract from April quarterly: Elementary Placer Mining Methods and Gold Saving Devices. Types of Deposits, Simple Equipment. Special Machines. Dry Washing. Black Sand Treatment. Marketing of Products. Placer Mining Areas. Laws. Prospecting for Quartz Veins. Bibliography (mimeographed) — Free, postage $0.05	.05
**July-October, (Ventura.) Report accompaning Geologic Map of Northern Sierra Nevada. Fossil Plants in Auriferous Gravels of the Sierra Nevada. Glacial and Associated Stream Deposits of the Sierra Nevada. Jurassic and Cretaceous Divisions in the Knoxville-Shasta Succession of California. Geology of a part of the Panamint Range. Economic Report of a Part of the Panamint Range. Acquiring Mining Claims Through Tax Title. The Biennial Report of State Mineralogist	----
Chapters of Report XXIX, 1933 (quarterly): titled 'California Journal of Mines and Geology,' containing the following:	
January-April. Gold Deposits of the Redding and Weaverville Quadrangles. Geologic Formations of the Redding-Weaverville District, Northern California. Geology of Portions of Del Norte and Siskiyou Counties. Applications of Geology to Civil Engineering. The Lakes of California. Discovery of Piedmontite in the Sierra Nevada. Tracing 'Buried River' Channel Deposits by Geomagnetic Methods. Geologic Map of Redding-Weaverville District, showing gold mines and prospects. Geologic map showing various mines and prospects of part of Del Norte and Siskiyou Counties — Price $1.00, sales tax $0.03	1.03
July-October. Gold Resources of Kern County. Limestone Deposits of the San Francisco Region. Limestone Weathering and Plant Associations of the San Francisco Region. Booming, Death Valley National Monument, California. Placer Mining Districts, Senate Bill 480. Navigable Waters, Assembly Bill 1543 — Price $1.00, sales tax $0.03	1.03
Chapters of Report XXX, 1934 (quarterly): titled 'California Journal of Mines and Geology,' containing the following:	
January. Resurrection of Early Surfaces in the Sierra Nevada. Geology and Mineral Resources of Northeastern Madera County. Geology and Mineral Deposits of Laurel and Convict Basins, Southwestern Mono County. Notes on Sampling as Applied to Gold Quartz Deposits — Price $0.60, sales tax $0.02	.62
April-July. Elementary Placer Mining in California and Notes on the Milling of Gold Ores — Price $1.00, sales tax $0.03	1.03
**October. Current Mining Developments in Northern California. Current Mining Activity in Southern California. Geology and Mineral Resources of the Julian District, San Diego County. Geology and Mineral Resources of Elizabeth Lake Quadrangle. Dry Placers of Northern Mojave Desert. Biennial Report of State Mineralogist. Assessment Work Within Withdrawn Areas	----
Chapters of Report XXXI, 1935 (quarterly): titled 'California Journal of Mines and Geology,' containing the following:	
January. Review of Gold Mining in East-Central, 1934. Current Mining Activities in the San Francisco District with Special Reference to Gold. Geological Investigation of the Clays of Riverside and Orange Counties, Southern California. Information regarding Mining Loans by the Reconstruction Finance Corporation — Price $0.60, sales tax $0.02	.62

REPORTS—Continued

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April. A Geologic Section Across the Southern Peninsular Range of California. New Technique Applicable to the Study of Placers. Grubstake Permits Price $0.60, sales tax $0.02	$0.62
July. Mines and Mineral Resources of Siskiyou County (with map). Dams for Hydraulic Mining Debris. Leasing System as Applied to Metal Mining. Mine Financing in California. New Laws Make Radical Change in Mining Rights Price $0.60, sales tax $0.02	.62
October. Mines and Mineral Resources of San Luis Obispo County. Mineral Resources of Portions of Monterey and Kings Counties. Mining Activity at Soledad Mountain and Middle Buttes—Mojave District, Kern County. Geology of a Portion of the Perris Block, Southern California. Mineral Resources of a Portion of the Perris Block, Riverside County Price $0.60, sales tax $0.02	.62
Chapters of Report XXXII, 1936 (quarterly): titled 'California Journal of Mines and Geology,' containing the following:	
January. Gold Mines of Placer County, including Drag-line Dredges. Geologic Report on Borax Lake, California Price $0.60, sales tax $0.02	.62
April. Geology, Mining and Processing of Diatomite at Lompoc, Santa Barbara County. Essentials in Developing and Financing a Prospect into a Mine. Gold-bearing Veins of Meadow Lake District, Nevada County. Semi-Precious Gem Stone Collection in Division Museum Price $0.60, sales tax $0.02	.62
July. Mines and Mineral Resources of Calaveras County. Mining in California by Power Shovel. Assessment Work on Mining Claims Within Withdrawn Areas. Joshua Tree National Monument. Cost of Producing Quicksilver at a California Mine in 1931-1932. The Age of Mineral Utilization Price $0.60, sales tax $0.02	.62
October. Mineral Resources of Lassen and Modoc Counties. Mechanics of Lone Mountain Landslides, San Francisco. Biennial Report of the State Mineralogist, Properties and Industrial Applications of Opaline Silica Price $0.60, sales tax $0.02	.62
Chapters of Report XXXIII, 1937 (quarterly): titled 'California Journal of Mines and Geology,' containing the following:	
January. Source Data of the Geologic Map of California, January, 1937. The Geology of Quicksilver Ore Deposits. Prospecting for Lode Gold Price $0.60, sales tax $0.02	.62
April. Mineral Resources of Plumas County (with Geologic Map). List of preferred mineral names. New Placer Mining Debris Law Price $0.60, sales tax $0.02	.62
July. Mineral Resources of Los Angeles County (with map showing principal Mines and Oil Fields.) Geology and mineral deposits of the Western San Gabriel Mountains, Los Angeles County Price $0.60, sales tax $0.02	.62
October. Mineral Resources of the Resting Springs Region, Inyo County. Paleozoic Section in the Nopah and Resting Springs Mountains, Inyo County, California. Native Arsenic from Grass Valley, California Price $0.60, sales tax $0.02	.62
Chapters of Report XXXIV, 1938 (quarterly): titled 'California Journal of Mines and Geology,' containing the following:	
January. Mineral Development and Mining Activity in Southern California during the year 1937. Doing Something About Earthquakes. Gold and Petroleum in California. Gem Minerals of California, Lapidary Art Price $0.60, sales tax $0.02	.62
April. Gold dredging in Shasta, Siskiyou and Trinity Counties; Geology of the Central Santa Monica Mountains; Marketing Mica Price $0.60, sales tax $0.02	.62
July. El Dorado County, Mineral High-Lights of California; Strategic Minerals of California; Cyanide Treatment of Gossan at Mountain Copper Co.; Submarine Canyons off the California Coast Price $0.60, sales tax $0.02	.62

REPORTS—Continued

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	Price (including postage and sales tax)
October, Inyo County, Biennial Report of State Mineralogist, Sulphur Deposits of Inyo County, Geology of the Darwin Silver-Lead Mining District Price $0.60, sales tax $0.02	$0.62
Chapters of Report XXXV, 1939 (quarterly) titled "California Journal of Mines and Geology," containing the following:	
January, San Diego County, Geology and Oil Possibilities of Southwestern San Diego Co.; Prospect for 'Minor Metals' and Nonmetallic Minerals; The Right to Mine Price $0.60, sales tax $0.02	.62
April, Shasta County, Public's Interest in Mine Taxation Price $0.60, sales tax $0.02	.62
July, Tertiary Formations of Northern Sacramento Valley, California; Geology and Oil Possibilities of Caliente Range, Cuyama Valley and Carrizo Plain, California; Bibliography of the Geology and Mineral Resources of California for the year 1937; The Giant Goose Lake Meteorite from Modoc County, California Price $0.60, sales tax $0.02	.62
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Map of Northern California, showing rivers and creeks which produced placer gold in 1932 Price $0.25, sales tax $0.01	.26
Mother Lode Geologic and claim maps in 5 county sections: El Dorado, Amador, Calaveras, Tuolumne and Mariposa. Single sections .25c. Set of 5 Price $1.00, sales tax $0.03	1.03
Map of Mariposa County, showing principal gold mines Price $0.25, sales tax $0.01	.26
Geologic Map of Elizabeth Lake Quadrangle, Los Angeles and Kern Counties (accompanying October Chapter of Report XXX), sold separately Price $0.25, sales tax $0.01	.26
Map of Western Portion of Siskiyou County Showing Location of Principal Gold Mines (accompanying July Chapter of Report XXXI), sold separately Price $0.25, sales tax $0.01	.26
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Quicksilver deposits, sold in conjunction with Oct. 1939, Chapter of Report XXXV Price $0.50, sales tax $0.02	.52
Nevada County (Accompanying July chapter of Report XXXVII) Price $0.25, sales tax $0.01	.26
Oil Fields Map Price $1.00, sales tax $0.03	1.03

OIL AND GAS FIELD MAPS

March 1, 1941.

The following maps are on sale at the State Division of Oil and Gas, Ferry Building, San Francisco, and the various branch offices. The maps are revised as development work advances and ownerships change. Price includes postage and sales tax.

No.	*Price*
1—Sargent, Santa Clara County	$0.75
2—Santa Maria, including Cat Canyon—Los Alamos, Santa Barbara County	1.25
3—Santa Maria, including Casmalia and Lompoc, Santa Barbara County	1.25
4—Brea-Olinda, east portion Coyote Hills, Los Angeles, Orange Counties	1.25
6—Salt Lake—Beverly Hills, Los Angeles County	1.25
7—Sunset, including San Emidio, Kern County	1.25
8—South Midway, including Buena Vista Hills, Kern County	1.25
9—North Midway and McKittrick, Kern and San Luis Obispo Counties	1.25
10—Belridge and McKittrick Front, Kern County	1.25
11—Lost Hills and North Belridge, Kern County	1.25
12—Devils Den, Kern County	1.00
13—Kern River, Kern County	1.00
14—Coalinga and East Coalinga Extension, Fresno County	1.50
15—Elk Hills, Kern County	1.25
16—Ventura-Ojai, Ventura County	1.25
17—Santa Paula-Sespe, Bardsdale, South Mountain, Camarillo, Ventura County	1.25
18—Piru, Simi, Newhall, Aliso Canyon, Del Valle, and Newhall-Potrero, Ventura and Los Angeles Counties	1.25
19—Arroyo Grande, San Luis Obispo County	1.00
20—Long Beach, Los Angeles County	1.75
21B—District 5, boundaries of areas including oil fields, Fresno, Kings and Kern Counties	1.00
21C—District 4, boundaries of areas including oil fields, Kern, Kings and Tulare Counties	1.25
22—District 3, boundaries of areas including oil fields, Santa Barbara County	.75
23—District 2, boundaries of areas including oil fields, Ventura County	1.00
24—District 1, boundaries of areas including oil fields, Los Angeles and Orange Counties	1.00
26—Huntington Beach, Orange County	1.50
27—Santa Fe Springs, Los Angeles County	1.25
28—Torrance, Los Angeles County	1.25
29—Dominguez, Los Angeles County	1.00
30—Rosecrans, Los Angeles County	1.25
31—Inglewood, Los Angeles County	1.25
32—Seal Beach, Los Angeles and Orange Counties	1.25
33—Rincon, Ventura County	1.50
34—Mt. Poso and Poso Creek, Kern County	1.00
35—Round Mountain, Kern County	1.00
36—Kettleman North Dome and Middle Dome, Fresno and Kings Counties	1.50
37—Montebello, Los Angeles County	1.00
38—Whittier, Los Angeles County	1.25
39—Coyote Hills (west portion), Los Angeles and Orange Counties	1.25
40—Elwood, Goleta (abandoned), La Goleta (gas), Santa Barbara County	1.25
41—Potrero, Los Angeles County	1.00
42—Playa del Rey, Los Angeles County	1.50
43—Capitan, Santa Barbara County	1.00
44—Mesa, Santa Barbara County	1.50
46—Richfield, Orange County	1.25
48—Mountain View and Edison, Kern County	1.25
49—Fruitvale, Kern County	1.00
50—Wilmington, Los Angeles County	1.25
51—Santa Maria Valley, Santa Barbara County	1.00
52—El Segundo and Lawndale, Los Angeles County	1.50
53—Rio Bravo and Greeley, Kern County	1.00

OIL AND GAS FIELD MAPS—Continued

No.	*Price*
54—Wasco oil field, Buttonwillow and Semitropic (gas), Kern County	$1.25
55—Canal, Canfield Ranch, Coles Levee, Strand, Ten Section, Kern County	1.25
56—Paloma, Kern County	1.25
Map No. 57—Rio Vista Gas Field, Solano County Price $1.00, sales tax $0.03	1.03
Map No. 58—Trico Gas Field, Kern, Kings and Tulare Counties Price $1.00, sales tax $0.03	1.03

DETERMINATION OF MINERAL SAMPLES

Samples (limited to two at one time) of any mineral found in the State may be sent to the Division of Mines for identification, and the same will be classified free of charge. No samples will be determined if received from points outside the State. It must be understood that no assays, or quantitative determinations will be made. Samples should be in lump form if possible, and marked plainly with name of sender on outside of package, etc. No samples will be received unless delivery charges are prepaid. A letter should accompany sample, giving locality where mineral was found and the nature of the information desired.

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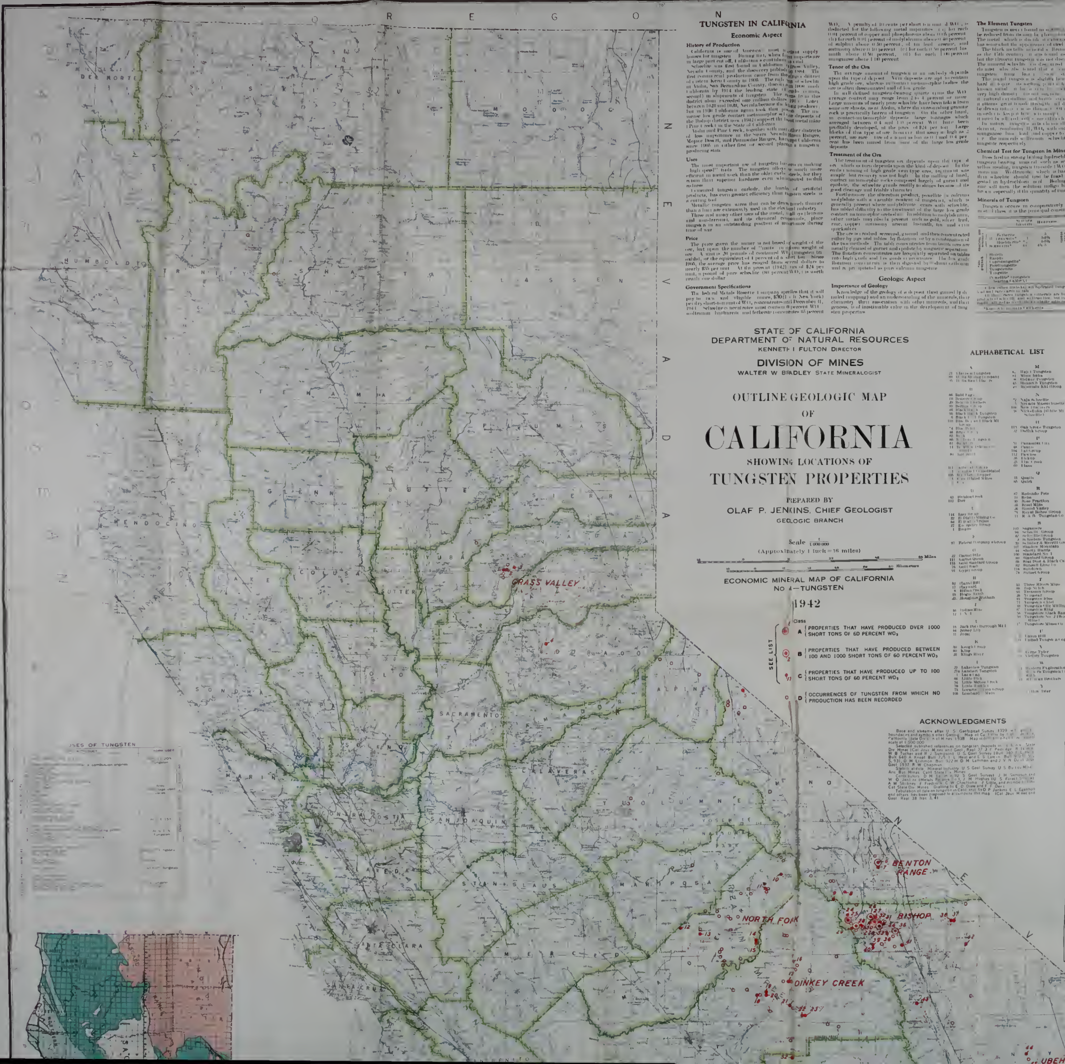


TUNGSTEN IN CALIFORNIA

Economic Aspect

History of Production

Uses

Price

Government Specifications

Tenor of the Ore

Treatment of the Ore

Geologic Aspect

Importance of Geology

The Element Tungsten

Chemical Test for Tungsten in Minerals

Minerals of Tungsten

Characteristics of Tungsten Mineralization

Geologic Processes

Geologic History

Regional Rock Structure and the Distribution of Tungsten

STATE OF CALIFORNIA
DEPARTMENT OF NATURAL RESOURCES
KENNETH I FULTON DIRECTOR

DIVISION OF MINES
WALTER W BRADLEY STATE MINERALOGIST

OUTLINE GEOLOGIC MAP OF CALIFORNIA SHOWING LOCATIONS OF TUNGSTEN PROPERTIES

PREPARED BY
OLAF P. JENKINS, CHIEF GEOLOGIST
GEOLOGIC BRANCH

Scale $\frac{1}{1\,000\,000}$
(Approximately 1 inch = 16 miles)

ECONOMIC MINERAL MAP OF CALIFORNIA
No 4—TUNGSTEN

1942

Class	
A	PROPERTIES THAT HAVE PRODUCED OVER 1000 SHORT TONS OF 60 PERCENT WO_3
B	PROPERTIES THAT HAVE PRODUCED BETWEEN 100 AND 1000 SHORT TONS OF 60 PERCENT WO_3
C	PROPERTIES THAT HAVE PRODUCED UP TO 100 SHORT TONS OF 60 PERCENT WO_3
D	OCCURRENCES OF TUNGSTEN FROM WHICH NO PRODUCTION HAS BEEN RECORDED

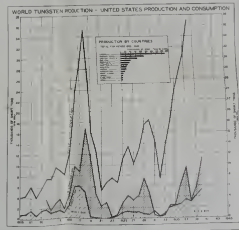
SEE LIST

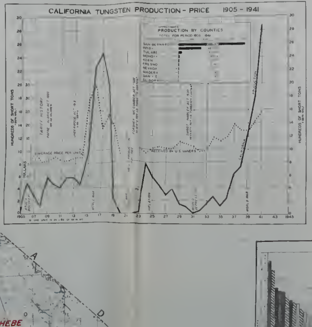
LIST OF PRINCIPAL TUNGSTEN PROPERTIES (Classes A, B and C only)

ALPHABETICAL LIST

GEOGRAPHICAL ARRANGEMENT

ACKNOWLEDGMENTS





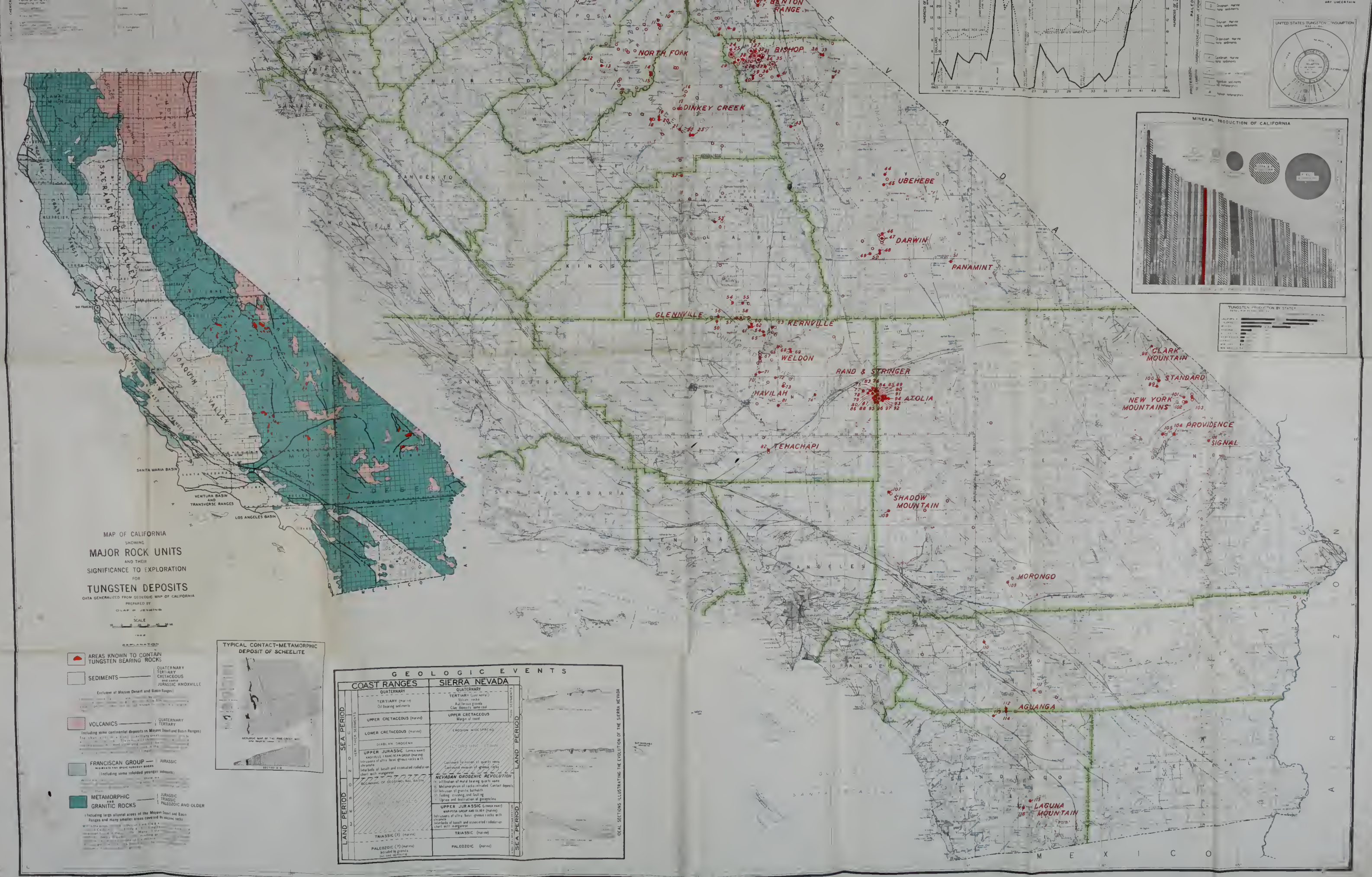
SEDIMENTARY ROCKS

IGNEOUS ROCKS

CENOZOIC
MESOZOIC
PALEOZOIC
PROTEROZOIC
CENOZOIC VOLCANICS

CULTURE

GEOLOGIC BOUNDARIES & FAULTS



MAP OF CALIFORNIA
SHOWING
MAJOR ROCK UNITS
AND THEIR
SIGNIFICANCE TO EXPLORATION
FOR
TUNGSTEN DEPOSITS
DATA GENERALIZED FROM GEOLOGIC MAP OF CALIFORNIA
PREPARED BY
OLAF P. JENKINS

SCALE

EXPLANATION

🟥 AREAS KNOWN TO CONTAIN TUNGSTEN BEARING ROCKS

☐ SEDIMENTS — QUATERNARY, TERTIARY, CRETACEOUS and some JURASSIC KNOXVILLE

Exclusive of Mojave Desert and Basin Ranges

VOLCANICS — QUATERNARY, TERTIARY

Including some continental deposits in Mojave Desert and Basin Ranges

FRANCISCAN GROUP — JURASSIC

Including some infolded younger sediments

🟩 METAMORPHIC AND GRANITIC ROCKS — JURASSIC, TRIASSIC, PALEOZOIC AND OLDER

Including large alluvial areas of the Mojave Desert and Basin Ranges and many smaller areas covered by volcanic rocks

TYPICAL CONTACT-METAMORPHIC DEPOSIT OF SCHEELITE

GEOLOGIC EVENTS

COAST RANGES

- QUATERNARY
- TERTIARY (marine) — Oil bearing sediments
- UPPER CRETACEOUS (marine)
- LOWER CRETACEOUS (marine)
- DIABLAN OROGENY
- UPPER JURASSIC (upper part) — KNOXVILLE FRANCISCAN GROUP (marine). Intrusions of ultra basic igneous rocks with chromite. Interbeds of basalt and associated radiolarian chert with manganese
- BEGINNING OF GEOSYNCLINAL BASIN
- RECORD CONCEALED
- TRIASSIC (?) (marine)
- PALEOZOIC (?) (marine) — Intruded by granite (no ore deposits)

SIERRA NEVADA

- QUATERNARY
- TERTIARY (continental) — Volcanic rocks. Auriferous gravels. Clay deposits, some coal
- UPPER CRETACEOUS — Margin of coast
- EROSION WIDESPREAD — RECORD UNCERTAIN — Continued formation of quartz veins. Continued invasion of igneous rocks
- NEVADAN OROGENIC REVOLUTION — (5) Infiltration of metal bearing quartz veins. (4) Metamorphism of rocks intruded. Contact deposits. (3) Intrusion of granitic batholith. (2) Folding, crushing, and faulting. (1) Uprise and destruction of geosyncline
- UPPER JURASSIC (lower part) — MARIPOSA GROUP AND OLDER (marine). Intrusions of ultra basic igneous rocks with chromite. Interbeds of basalt and associated radiolarian chert with manganese
- TRIASSIC (marine)
- PALEOZOIC (marine)

SEA PERIOD · LAND PERIOD · MESOZOIC · VERY THICK SEDIMENTS · THIN SEDIMENTS

IDEAL SECTIONS ILLUSTRATING THE EVOLUTION OF THE SIERRA NEVADA